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EXPERIMENTAL HORTICULTURE STATIONS

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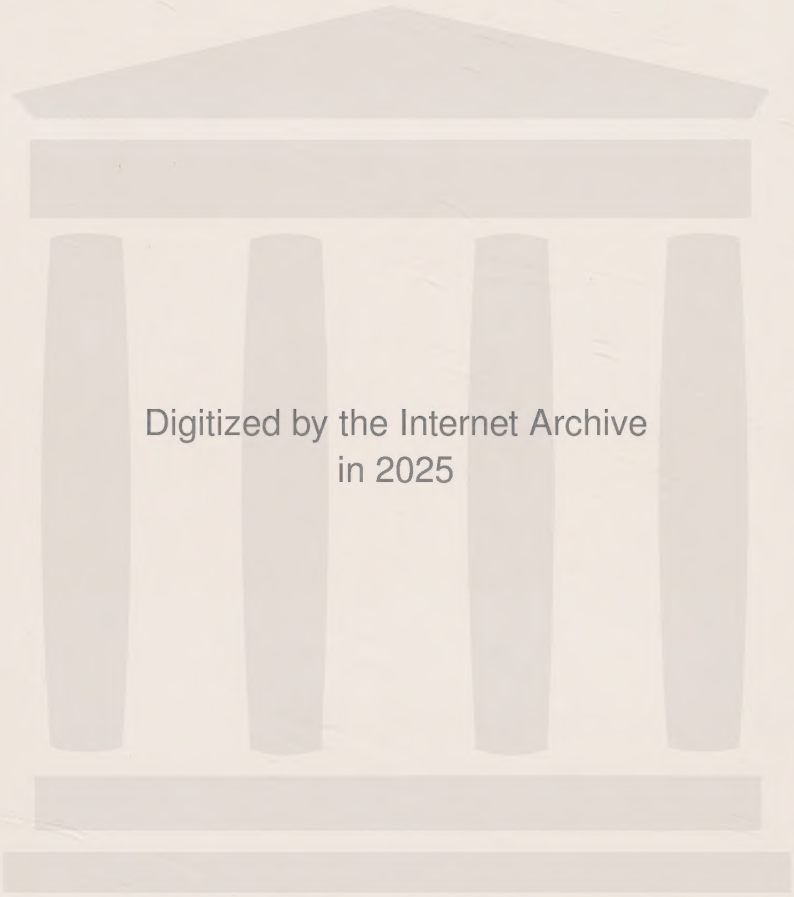
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Introduction

This is the ninth Progress Report on experimental work at the N.A.A.S. Experimental Husbandry Farms and Horticulture Stations.

The Report does not attempt to review the whole field of investigations in progress in any one year but presents a selection of topics of particular interest, either because they are new to the experimental programme or because they have reached a stage where conclusions of practical importance can be reported.

For a fuller account of experiments being undertaken, other publications are available. Each centre prepares an Annual Report written mainly for the farmer and horticulturalist, which can be obtained from the Director concerned (address on pp. 93–5). In addition, at the conclusion of most experiments the results are reported in Experimental Husbandry, Experimental Horticulture or other scientific or technical journals.

Results from Recent Experiments

MAINCROP POTATO SEED STORAGE AND CHITTING

PART I: SEED CROPS

E. J. Mundy, *Norfolk Agricultural Station**

The management of potatoes grown for seed production is aimed at producing a good crop, with a high proportion of tubers within the seed size category of $1\frac{1}{4}$–$2\frac{1}{4}$ inches. To achieve this a high plant population is desirable. Under most conditions this is best achieved by planting multi-sprouted seed at 9–15 inch spacing, so producing a large number of tubers, the growth of which tends to be restricted by plant competition.

Lifting

Under Yorkshire Wold conditions it is considered advantageous to burn off in August the haulm of a crop grown for seed, to prevent the influx and spread of aphids in the crop and thus to control the spread of virus. Since haulm destruction takes place before the potatoes are mature, it is necessary to delay harvesting to allow the potatoes to harden off.

Storage

During lifting and handling the potatoes suffer mechanical damage in the form of cuts and bruises. The extent of the damage will depend on soil type and method of harvest, but even under ideal conditions some will occur. In order to store safely, potatoes coming into store or clamp should be allowed a curing period when the temperature of the potato mass should be encouraged to rise to about 65°–70°F (18·3–21·1°C) for a period. During this time damaged tubers will heal rapidly and the risk of storage rots is reduced. After the curing period the temperature is best dropped by ventilation, to prevent premature sprouting and reduce weight loss. Wet loads should be kept out of bulk store as their inclusion is likely to contaminate the whole mass and cause heavy storage loss; they need to be kept separate and dried out as quickly as possible.

In bulk stores it is important to provide ventilation ducts under the potatoes to assist in the control of temperature and moisture condensation. The exposed surfaces of potatoes in these stores should be well covered with straw to at least 12 inches, so that moisture brought up by warm air rising through the potatoes will condense in the straw and not on the potatoes. If there are any signs of dampness on the top potatoes more straw should be added. Excessive moisture is usually a sign of heating lower down, and if increased ventilation and more straw fails to dissipate the trouble, then early riddling is desirable to reduce the danger of trouble spreading throughout the whole mass.

Disease Control in Store

The prevention of the spread of disease affecting the quality of seed potatoes

*Previously at High Mowthorpe Experimental Husbandry Farm.

is important. One of the most troublesome of these is skin spot caused by the fungus *Oospora pustulans*. It is known that damp cold storage conditions favour the spread of the fungus, hence the importance of storing seed stocks dry. The fungus is widespread and occurs on most stocks of potatoes, but only causes trouble when the infection is allowed to build up during storage and the heavily infected seed is planted in cold wet conditions.

Over a three year period at High Mowthorpe, studies on the build up of skin spot infection of Majestic seed potatoes in a bulk store showed that at lifting 57 per cent of tuber eyes had the fungus present on them. By April the following year, one month after the potatoes had been taken out of bulk storage and bagged, 85 per cent of eyes were infected and 23 per cent of eyes were dead. Boxing the potatoes during the winter for chitting prevented spread of the fungus. If boxing took place before January, only 58 per cent of eyes were infected and less than 10 per cent of the total were dead at planting in April. Delaying boxing until January or February restricted a further spread of the fungus, but eye death was a little higher than in earlier boxed seed; however it was much less than when seed was not boxed at all. Thus boxing of seed provides an effective method of controlling the effects of skin spot infection, as well as encouraging the seed tubers to make vigorous early growth when planted.

It must also be realized, however, that good seed is often spoilt by bad handling by the purchaser. When seed arrives on the farm it should be carefully inspected, and only accepted if it is of the specified size and of good appearance. After transport and handling, often during a cold time of year, it is advisable to allow the seed a curing period to heal damage caused during transport. Stacking the seed in a warm shed and covering it to allow a build-up in humidity will reduce the risk of gangrene. This disease, caused by a fungus (*Phoma foviata*), is most active under cold dry conditions. The fungus enters the tubers where the skin has been damaged, and provision of a curing period is an effective method of reducing losses from this disease.

Advantages of Chitting

The boxing and chitting of seed to be grown on for seed production is recommended for English conditions, particularly in areas where the length of the growing season is short. The increased total yield resulting from chitting will more than repay the additional cost of the operation. At high Mowthorpe, where maincrop Majestic potatoes were planted for seed production in April, the mean total yield response to chitting in seven of the past eight years has been 1·8 tons per acre. This additional yield had been made up of an increase of 2·1 tons per acre ware, over $2\frac{1}{4}$ inch, and a small reduction of 0·3 ton per acre in the yield of seed. In the one year, not included in the mean figures given, seed which had not been pre-sprouted failed to produce a reasonable plant and the area was replanted at a later date, whereas chitted seed produced a normal crop. As planting becomes later, so the response to chitting has been found to increase and the reduction in seed yield becomes negligible. Chitted seed gives a vigorous plant and produces more main stems and hence more tubers. Over the period 1963 to 1965 chitted seed produced a mean of 4·2 main stems per set compared to 2·6 stems per set from non-chitted seed.

Sprouts grown to $\frac{2}{3}$ inch and well-greened appear to be best suited to

hand and semi-automatic machine planting. Experience at High Mowthorpe suggests that a shorter sprout is preferable when a fully automatic planter is used, as long sprouts suffer more damage. A multi-sprout set is desirable for seed production, and with the variety Majestic it has been found that breaking dormancy in February by raising the storage temperature to 50°F (10°C) gives good sprout development. Once dormancy has been broken, adequate lighting is essential to prevent etiolation and the rate of sprout growth should be slowed by reducing the temperature in the chitting house, unless very early planting can be carried out. Prior to planting, sprouted seed should be hardened off by opening up the chitting house for maximum ventilation.

Chitting out of Doors

A small tonnage of Majestic potatoes has been successfully chitted out of doors under polythene over the past three years at High Mowthorpe. Two stacks, each of 160 standard chitting trays, were constructed in late February or early March each year. The boxes were stacked in four rows, placed with a passage down the centre, each row being five boxes in length and eight high. A double pitch roof frame was constructed over the stack and, after suspending soil warming cables in loops from the top boxes, the whole stack was covered by a 20×24 ft clear polythene sheet (1000 gauge). Each year one stack was heated by 1·2 kW soil warming cables with a thermostat control initially set at 50°F. The other stack was provided with less heat in 1965 and 1966 and none at all in 1967.

The resultant crop from seed chitted in the warmer stacks was similar in growth and yield to that from seed boxed in January and chitted indoors. Seed chitted in the cool stack was less advanced at planting and the resultant crop yielded approximately 1 ton per acre less than the seed in the warm stack. Without heat in 1967, temperature records showed that the maximum temperature in the non heated stack was always at least 5°F (2·8°C) above the outside minimum temperature. The stacks at the farm were in relatively sheltered conditions, protected by buildings to the north and east; the risk of frost damage appears to be slight when stacks are built from late February onwards. However, for the variety Majestic, the provision of heating is justified in terms of increased yield.

Chitting out of doors under polythene does not require high capital investment, particularly if it is decided not to invest in heating. The system may best be used as a means of chitting small quantities of seed, either for the small grower or as an extension to existing chitting facilities.

In all instances careful handling and inspection of seed during storage and chitting will repay the seed grower for his efforts.

PART II WARE CROPS

F. E. Shotton, *Terrington Experimental Husbandry Farm*

The sprouting of seed potatoes prior to planting can have four main effects, some or even all of which may result in a commercial advantage in a particular situation:

1. Sprouting will lead to speedier emergence and hence to earlier bulking.
2. As a consequence of this, the final yield at maturity may be increased.
3. A particular technique of sprouting may enable the grower to influence the number of tubers per 'hill' and hence, tuber size.
4. Putting tubers into trays enables them to be examined prior to planting and diseased tubers to be discarded. If conditions in the sprouting house can be regulated it may also be possible to reduce the severity of diseases such as gangrene and skinspot.

Aspect 3. is particularly relevant to seed production and has been dealt with in Part I. Tuber disease control is not the subject of this article so, important as it is, we shall largely ignore item 4. Of the remaining two, item 1. is of the greatest general consequence to early growers and item 2. to main-crop ware producers. In both cases the increase in yield results from a lengthening of the period during which the crop carries an effective cover of foliage. There are numerous trial results to show that sprouting will increase ware yield and this is usually true whether the crop is planted early or late. There are also quite a number of trials which show that early planting, in the absence of late frosts, will increase potato yield, but there are fewer trials to show the interaction of planting date and sprouting.

Sprouting in Relation to Planting Date

One such series was carried out at 15 centres in East Anglia from 1958–60. Averaged over all centres, the effect on the ware yield of King Edwards was: when planted early (mean date 6 April) sprouting gave an increase of 2·1 tons per acre; when planted late (mean date 5 May) sprouting gave a larger increase of 3·2 tons per acre. At only three of the sites did sprouting fail to give an increase in yield and then only at the first planting date. These figures are impressive testimony to the value of sprouting at both dates of planting but they conceal the fact that, at 5 out of 14 of the sites at which the comparison can be made, early-planted unsprouted seed out-yielded sprouted seed planted about a month later.

It is difficult to know how one should interpret these results in practical terms which may be applicable over the whole coutry. Most potato growers will plant as soon as the condition of the land and other considerations allow them to get on. The weight of the evidence shows that sprouting is an economically profitable operation and that the yield reduction due to an enforced delay in planting will be lessened if the seed has been sprouted. But there are no doubt potato growing farms in the country where favourable aspect, freely draining soil and freedom from late frosts make early planting possible in most years, and in such situations it may be considered uneconomic to go to the expense, and also the additional trouble, involved in the sprouting process.

On the silty loam and silty clay loam soils at Terrington E.H.F. potato planting normally occurs during April. Rarely is it possible to get on the land in March and a small proportion of the crop may remain to be planted in May. In these circumstances sprouting has normally given a very worthwhile increase in the yield of maincrop ware, and seed sprouting, traditionally in glass chittinghouses, is standard practice on most farms in the surrounding area.

Type of Sprouting House

Since 1957 experiments have been conducted on the E.H.F. with the object of finding out whether it is possible, by adjusting the conditions under which the setts are sprouted, to affect either the yield of the crop or the ease of mechanical handling of the setts during planting. To enable these experiments to be conducted an experimental store was erected. This was an insulated windowless building having two compartments lit by fluorescent tubes and with temperature control effected by the circulation or re-circulation of air. A third compartment was fitted with a cooling plant which would maintain it at a temperature down to 35°F (1·7°C) but which was normally controlled at about 38–40°F (approx. 4°C). Inside this chamber are five cabinets in each of which up to 5 cwt of tubers in chitting trays can be kept at a temperature above that of the main chamber, each having its own heating unit, circulating fan and light tube.

In the first trials the performance of tubers stored in the new experimental store was compared with that of seed sprouted in the glass chittinghouse. Over five years (1957–61), and working with the varieties Majestic, King Edward and Arran Pilot, differences due to the type of sprouting house were neither very large nor very consistent. Seed sprouted in the new experimental store did, however, produce slightly higher yields than resulted from chitting under glass, the difference ranging from 11 cwt per acre for Majestic to 4 cwt per acre for King Edward. This was not due to a better control over sprout growth, as the sprouts produced in the glass chittinghouse for both Majestic and King Edward averaged about $\frac{1}{2}$ in. long whereas those from the new store were almost three times as long. With Arran Pilot the same relationship held but sprouts were twice as long as those of the other two varieties.

These results suggested that farmers having glass chittinghouses had no need to consider changing to other types but that, if a new building had to be erected, it would serve its original purpose rather better if it were an artificially illuminated and insulated store and also might well prove more adaptable for other purposes outside the potato spouting period. Alternatively, the installation of lights and fan ventilation in an existing barn or similar building could be expected to make it quite suitable for potato sprouting.

Effects of Light and Temperature During Sprouting

The effects of varying the period of illumination and the temperature during sprouting have been studied in other experiments. In the illumination work 'warm-white' fluorescent tubes were suspended in front of the trays of

experimental potatoes and were lit for a certain period each day from 1 February until planting. The illumination periods tested, and their effect on the growth of the apical sprout at planting time, are shown in Table 1.

TABLE 1

Mean length of apical sprout (in.)

Period of illumination (hours/day)		6	12	18	24
1957–60	Majestic	1·31	1·11	1·00	0·95
	King Edward	1·83	1·27	1·03	0·97
	Arran Pilot	3·80	3·85	2·92	3·50
Period of illumination (hours/day)		1½	3	6	12
1961, 62, 64	King Edward	1·59	1·32	0·92	1·03
	Arran Pilot	3·17	3·69	3·13	2·57

It will be seen that there was a fairly clear tendency for increasing light to reduce sprout length to some extent but, in the context of mechanical planting, almost all the sprouts, and especially those of Arran Pilot, were too long. In the 1962–64 series the effect of reducing the intensity of illumination was studied by filtering the light through scrim (loosely-woven linen). This showed that brighter light was more effective for shortening the sprouts than dim illumination of the same duration, though the effect was rather less than expected.

TABLE 2

Mean length of apical sprout (in.)

		Bright	Dim
1961, 62, 64	King Edward	1·10	1·33
	Arran Pilot	2·71	3·57

These trials showed no consistent effect from varying the period of illumination during sprouting on the final yield of the crop.

The experiments on the effect of temperature were conducted in the controlled temperature cabinets already referred to. These were held at 45°, 55°, 65° or 75°F (7°, 13°, 18° and 24°C) and in a fifth cabinet the temperature rose to 75°F by day and fell to 55°F at night as might perhaps happen in a glass chittinghouse. Each cabinet was illuminated for 10½ hours per day from 1 February until planting. In this trial the effect on sprout growth was much more pronounced.

TABLE 3

Mean length of apical sprout (in.)

Storage temperature (°F)		45	55	65	75	55/75
1957–60	Majestic	0·41	1·31	1·41	1·14	1·03
	King Edward	0·44	1·35	1·23	0·98	1·05
	Arran Pilot	0·99	4·91	3·41	1·11	1·47

Not only was the effect clear but the lowest temperature, 45°F, produced acceptably short sprouts on Majestic and King Edward and even on Arran Pilot they were not unduly long. Temperature during sprouting has therefore a much greater effect than illumination and if temperature is allowed to rise to 55°F unduly long sprouts result, even if illuminated for 10½ hours daily. This explains to some extent the sprout lengths in the illumination trial, for it was not always possible, simply by ventilation, to keep the temperature below 50°F.

It is interesting, from an academic point of view, to note that when the temperatures exceeded 65°F, the sprout length again became shorter whether the temperature was kept constant at 75° or allowed to fluctuate. This is not likely to be an economic method of controlling sprout growth and the sprouts produced at such high temperatures are abnormally globular in form and are easily broken off the tuber.

The effect of the various storage temperatures on yield was rarely very large but, with all three varieties, the tubers sprouted at 45° gave very slightly the highest yield, while those sprouted at 75° showed an appreciably lower yield than was obtained from the other storage temperatures. From this it became clear that, if the temperature can be kept down to 45°, not only will the sprouts be most suitable for mechanical planting but the best yield will also be obtained.

In passing one might here remark that higher temperatures are sometimes advocated in order to reduce eye destruction by the skin spot fungus. Our results suggest that once the eyes have 'opened', and thus become safe from skin spot attack, the temperature should again be dropped to 45° or below to prevent excessive elongation of sprouts.

SPROUTING FOR MECHANICAL PLANTING

All the trials so far mentioned were planted by hand. During recent years fully-automatic planters, which require either no labour on the machine or only one person to a multi-row machine, have been introduced and have excited considerable interest because of their obvious labour economy and because, freed from the speed restriction imposed by hand operatives, they also plant faster than semi-automatic machines. Such machines cause one to look again at sprouting techniques because these machines handle the seed less gently than human hands and hence sprouts need to be tougher. Furthermore, long sprouts would impede the flow in the hoppers so that short tough sprouts become not only desirable but essential. To achieve such sprouts it has been suggested that the period of sprouting should be

shortened, as this is the only certain way of ensuring short sprouts on most farms.

A series of hand planted trials from 1958–62 examined the effect of sprouting for varying lengths of time and, during the later years of the series, the starting dates for sprouting were 1 December, 1 January, 1 February and 1 March. Until the prescribed date the seed was held at about 38°F (3·3°C) in the cool store; the unsprouted control seed being held at this temperature until just a few days before planting. From these trials it was clear that a short sprouting period would certainly lead to the production of shorter sprouts but there were also effects on final yield. With Majestic the figures show a fairly marked and fairly consistent decline in yield as the sprouting period became shorter. With King Edward the position is less clear and in some seasons March sprouting did not give inferior yields to those resulting from longer periods of sprouting. Unfortunately climatic conditions during the growing season interact with the sprouting treatment and thus lead to inconsistency in results from one season to another. Such a case occurred with King Edward in 1962 when a severe late frost on 31 May cut back the earlier growth produced on tubers which had had a longer sprouting period, but had little effect on the rate of emergence of unsprouted and March-sprouted seed. In that year March-sprouted seed gave higher yields than were obtained from a longer sprouting period. Similarly, especially with Arran Pilot when allowed to grow to maturity, it has been observed that late-sprouted or unsprouted seed may profit from July rain following a dry period in May and June, more than earlier-sprouted seed which is beginning to mature and makes little further growth by that time. Such a year was 1961 when unsprouted Arran Pilot gave a higher mature yield than all the sprouting treatments.

On balance however, with Majestic and, to a lesser extent, King Edward, the evidence to 1962 suggested that very short sprouting period would give lower yields than a longer one although it would still outyield unsprouted seed by a considerable margin.

Further trials are now in progress to examine the effect of a short period of sprouting on sprout growth and on yield, with an eye to the requirements of the fully-automatic planter.

As yet it is too early to present a considered summary of this incomplete series but it appears, from present results, that there may be varietal differences in response to the length of the sprouting period. Majestic has again shown a higher yield from a long than from a short sprouting period. In two years King Edward yielded about 8 cwt per acre less ware from mid-March sprouting than from late January sprouting, but in the third year gave an equal yield and thus showed a mean loss of 6 cwt per acre of ware over three years. In contrast, in two years in hand planted trials, Pentland Crown gave a higher yield from March than from January sprouting. Unfortunately this result is inexplicably contradicted by another trial with Pentland Crown in 1967, which was planted with a fully-automatic planter and in which January-sprouted seed outyielded March-sprouted.

Eventually it must be decided whether the use of an automatic planter is economic. The advantages of such planters in speed of planting are clear and, if this enables the average planting date to be advanced by, let us say a week, there should be some gain in yield. If, on the other hand, the planter

replaces a hand planting gang and takes no less time, there would be a saving in the cost of casual labour which, on a reasonably large potato acreage, should exceed the additional cost incurred by the purchase of the planter. There may be some saving of labour cost by changing from semi-automatic to fully-automatic machine planting but this could be more apparent than real if the planting had in fact been done by regular farm staff. Against such savings, our results suggest that one should be prepared to offset the value of a reduction in yield of $\frac{1}{4}$ to $\frac{1}{2}$ ton per acre of ware for the older varieties (though this may not be the case with Pentland Crown) if, in order to achieve short sprouts suitable for the planter, one adopts a shorter sprouting period. If possible it would be better to set out to achieve short sprouts by keeping the seed in the range 40–45°F over a longer sprouting period. What seems quite clear from our results is that, in situations such as our own where sprouting will increase ware yields by about 1 ton per acre, it would be wrong to forego the benefit of sprouting and to revert to the use of unsprouted seed in order to use a fully-automatic planter. Only if the choice lay between retaining a profitable potato enterprise or giving it up due to labour shortage and consequent inability to plant the crop by other methods, should such a drastic change be contemplated. And there can be few farms where there is adequate labour to lift the crop and yet insufficient to plant it.

SILAGE MAKING IN TOWERS AND CLAMPS

R. B. Mair, *High Mowthorpe Experimental Husbandry Farm*

Whilst tower silos are becoming a fairly common feature of the farming landscape, the effect that their introduction is having on the efficiency of grassland utilization is still a matter of debate. Surveys carried out in various parts of the country suggest that towers are usually a more efficient method of conserving forage than are clamps or pits, but they are more costly than clamp silos. The problem on the individual farm is to assess whether the increase in efficiency will be large enough to compensate for the increase in capital costs. The differences in efficiency observed on commercial holdings operating various systems of silage making are usually due to a combination of factors, and cannot be said to be due solely to the introduction of a particular system of conservation. It was therefore felt that a careful study of a tower system and a clamp system of silage making was necessary, in which the same type of grass, cut at the same time, was used in both systems. Two Experimental Husbandry Farms, Bridget's and High Mowthorpe, made this comparison over two seasons, each having a system based on a tower silo running alongside a clamp system. Great House have studied dry matter losses in a concrete tower silo.

Although the techniques employed in operating the two systems of conservation at Bridget's and High Mowthorpe were slightly different, the basic essentials were identical at the two farms. Leys were mown in May or early June, at early heading stage, and the crop was wilted in the field to between 25 per cent and 30 per cent dry matter before being led to clamp silos, and to between 35 per cent and 40 per cent in the tower systems.

The clamps were filled by buck-rake before being covered with polythene and the higher dry matter material was blown into the vitreous enamelled steel 18 × 40 ft top-unloaded towers. Timings of the harvesting operations were recorded and all the material was weighed and sampled at filling and again at feeding. Assessment of feeding quality was also made so that the two systems, at each farm, could be compared on the basis of output per acre, per unit of labour and machinery, and an estimate made of costs. The total effect of conservation on labour utilization could not be studied, as the need to record weights and analyses of the silages out of store did not allow the mechanical efficiency of the systems of feeding to be compared. In view of the variety of possible systems, this could only be assessed by survey work. Nevertheless this important consideration must be borne in mind when assessing the application of these results to commercial conditions.

Losses of Dry Matter Yield

Field losses

Losses of dry matter, and therefore of feeding value, occur at all stages, from mowing to feeding in the process of forage conservation. Field losses, due to respiration, leaching and mechanical damage, occurred in both systems but were higher in the tower system, where a longer wilting period was necessary to achieve the higher dry matter content.

At Bridget's, operations in the field resulted in an average loss of dry matter of 13·6 per cent between mowing and loading in the tower system, compared to 7·9 per cent for the clamp. In 1965 the average dry matter content of the material going into the tower was 44·6 per cent and rain delayed wilting, whereas in 1966 a deliberate attempt was made to examine the effect of storing at a lower dry matter, so wilting was not so prolonged and the crop was stored at an average dry matter of 34·2 per cent, at which point effluent ran out of the tower. This decreased the field loss, but greatly increased the in-store losses from 3·3 per cent with the drier material in 1965, to 15·1 per cent (see Table on page 11).

At High Mowthorpe the average dry matter content of the wilted grass blown into the tower was 40·1 per cent in 1965 and 35·7 per cent in 1966. Much higher losses occurred in 1965, for, as at Bridget's, showery weather resulted in a proportion of the grass lying in swath for several days before reaching a suitable dry matter content. The difference between the two years is illustrated when the weight of dry matter ensiled is compared with that available in the clamp system, where the average dry matter was around 27 per cent in both years. In 1965 the dry matter available to be ensiled in the tower, after wilting, was only 85 per cent of the weight ensiled in the clamp, from equal acreages of grass from the same fields mown on the same days; whilst in 1966 the equivalent figure was 94 per cent. Field losses during wilting can be a serious matter when trying to achieve high dry matters in adverse conditions, and it is apparent that seasonal differences are likely to occur.

Storage Losses

Tower storage reduced the amount of dry matter lost between the time of filling the silos and feeding. This is illustrated in the Table.

Loss and Waste of Dry Matter in Store
(Expressed as percentage of the dry matter ensiled)

Year	1965–6		1966–7	
Method of Ensiling	Tower	Clamp	Tower	Clamp
Bridget's	3·3	19·0	15·1	25·0
High Mowthorpe	9·8	16·0	3·3	13·1

In all four comparisons the loss of dry matter was higher in the clamp silos, but losses in the tower were very variable. The figures indicate that, under good conditions, the in-storage losses in a tower can be very small indeed but rise steeply when less suitable material is ensiled.

The level of dry matter loss in the clamps differed considerably between the two farms, averaging 22 per cent at Bridget's as against only 15 per cent at High Mowthorpe. A substantial difference between the type of comparison made at the two farms may go some way to explain this. At Bridget's, the aim was to compare the two methods of silage making as complete conservation systems in miniature, a first cut being used to fill the tower to approximately three-quarters of its final capacity, and to fill a small clamp which held about 100 tons of wilted material. Later the tower was topped-up with second-cut material, which was also used to fill another 100-ton clamp. At High Mowthorpe, only first-cut silage was used, to fill completely the tower and a 300-ton clamp. This suggests that the higher loss level at Bridget's may have been caused by the use of smaller clamps, while the contrasting low loss at High Mowthorpe may have been the result of using a bigger clamp which may have led to more effective exclusion of air. However, it must be remembered that, when whole systems of silage-making are considered, it may often be necessary in practice to ensile second cuts in relatively small quantities, which suggests that the High Mowthorpe clamp result may tend to be over optimistic. In view of these opposing biases at the two farms, average values for losses calculated from the results on both farms will probably be the best to apply to commercial practice, because the most realistic figures are likely to lie between those produced by the two farms. These average values for loss of dry matter in store (as per cent of D.M. ensiled) are 8 per cent and 18 per cent for the tower and clamp methods respectively.

At Great House the assessments made of dry matter losses occurring in a concrete silo, with a permanent aluminium roof and sealed plywood panels covering the filling holes, again showed wide variation. When care was taken to fill rapidly and to cover the herbage with a polythene sheet each night at the conclusion of filling, as little as 3·7 per cent of the dry matter was lost during storage. When this was not done, losses rose sharply and the highest figure recorded was 23·2 per cent loss. Other studies gave intermediate results.

Costs

In 1967 the N.A.A.S. devised a method for assessing the financial advantage or disadvantage of adopting the concrete stave tower system as against

clamps*. The method can be used to give overall guidelines or to inform decisions on individual farms. The depreciated capital costs of the two types of silo and their associated field equipment were worked out for various scales of operation, and it was found that, compared to clamp silage, tower silage had to bear an extra annual cost per ton of dry matter ensiled, primarily because of the high cost of the unloader and more elaborate field machinery. This ranged from £11 18*s*. with an 18 × 40 ft tower (50–60 tons D.M. capacity) down to £3 2*s*. with larger towers of 25 × 60 ft (200–240 tons D.M. capacity). This extra capital investment in a tower silage system has to be fully offset by increased financial returns (i.e., gross margins) or by savings in other costs, before it can be justified on any farm. Increased gross margins could result from the tower system if a substantial advantage in conservation efficiency (i.e., reduced D.M. yield losses) could be predicted for it with certainty, as compared with the clamp system. These improvements in gross margin could take three forms:

keeping the existing number of cattle on a reduced grazing and conservation acreage and releasing acres no longer required for conservation for use by other profitable enterprises;

the keeping of more cattle on an unchanged total acreage of grass, while maintaining the proportion of silage in the winter ration; and

keeping the acreage of grass and the cattle numbers the same as would be possible with clamp silage, but reducing the quantity of concentrates fed in the winter by increasing the proportion of silage in the diet.

The possible savings in costs would be most likely to be in terms of labour, that is, a reduction in the annual wages bill. This would not be dependent upon conservation efficiency, but upon higher output per man employed.

Improvement in gross margins

The first stage in the calculation of likely changes in gross margin is to state the relative conservation efficiencies of the tower and clamp systems. These are expressed as percentage losses of D.M. yield from cutting to feeding and must therefore include losses in the swath as well as in the silo. Unfortunately yields at cutting were not recorded at High Mowthorpe, so losses between cutting and ensiling cannot be calculated for that farm. However, the yield of dry matter available to be ensiled in the tower, after wilting, averaged 90 per cent of the weight ensiled in the clamp over the two seasons. This figure was very similar to the equivalent average of 94 per cent obtained at Bridget's. If the Bridget's field loss figures are adjusted from 13·6 per cent for the tower and 7·9 per cent for the clamp to 14·0 per cent and 7·0 per cent respectively, they alter the relative weight ensiled in the tower to 92 per cent of that put into the clamp, i.e., intermediate between the separate values for the two farms. When the average in-silo losses for both farms are calculated as percentages of the yield at cutting and are added to the adjusted field loss values, the total losses from cutting to feeding amount to 20·8 per cent for the tower and 24·0 per cent for the clamp. Thus the conservation efficiencies for the two systems differ by only 3·2 per cent and, as a consequence of this, there is virtually no possibility of recouping the extra capital cost of the tower system by raising gross margins, as follows:

*N.A.A.S. South East Region unpublished data.

1. the acreage reduction made possible by increased conservation efficiency was so small that, with stocking rates of 1 to 1·5 forage acres per livestock unit on the grass, the relatively small acreage of land released for other enterprises would have to yield gross margins of over £120 per acre to offset the extra cost of the tower, i.e., the £3 2*s*. per ton of forage D.M. applicable to large installations. This means that the alternative enterprise would have to be an usually high value cash root crop or horticultural crop, both of which are only grown on a minority of mixed dairy/arable farms.

2. Keeping more animals on an unchanged acreage while maintaining the level of silage feeding would also fail to cover the extra capital cost of £3 2*s*. per ton of silage D.M. Even with very well-managed cows yielding a gross margin, excluding variable forage costs, of £100 per animal per year, the increase in gross margin per ton of silage D.M. fed would amount only to £1 14*s*.–£2 0*s*. With beef cattle, giving a much lower gross margin per animal and per acre than dairy cows, there would be no recoupment at all.

3. Effective substitution of concentrates for silage in the winter ration is dependent upon the quality of the silage. On a dry matter basis, the feeding values of the two types of silage produced at Bridget's did not differ greatly, only a slightly improved digestibility in the tower silage being recorded. When the two silages were fed to dairy cows to provide 20 lb of dry matter per day and barley was fed at 4 lb per gallon for milk over about 1½ gallons per day, milk yields were very similar.

   At High Mowthorpe the silages were fed to beef cattle, and feeding trials with yearling Friesian cattle showed that, even though there was little difference in the feeding value of the dry matter of the two silages, cattle being offered the high dry matter material from the tower consistently had a higher intake of dry matter than cattle on the clamp silages. Consequently the tower silage, when fed to appetite, with low levels (3 lb/head/day) of supplementary barley, gave consistently better rates of live weight gain than cattle on the clamp silage. With higher levels of barley supplementing the silage, these differences in performance were reduced.

These feeding trial results suggested that it was physically feasible to feed a greater proportion of tower silage in the ration, in order to save concentrate costs, i.e., the third way of raising gross margins to cover the increased capital cost. However, calculations show that, even under the very favourable circumstances of high quality silage with a starch equivalent of 55 in the dry matter and concentrates for dairy cows costing £35 per ton, substitution of silage for concentrates would increase the gross margin per ton of silage D.M. by only £1 8*s*., i.e., only half the value needed to recoup the extra capital cost. With beef cattle an even poorer figure would be given, because the concentrates would cost only about £20 per ton.

Improvement in labour use

In terms of both labour and tractor time during silage making, the tower systems were more efficient at both Bridget's and High Mowthorpe. The two farms had very similar systems for filling the clamp using tipping trailers and buck-rakes, but Bridget's used two self-unloading trailers for the tower whilst High Mowthorpe used tipping trailers and a dump box.

At Bridget's the saving in tractor time was not large but, as the tower system was operated by two men less than the clamp system and transport of dry matter was more efficient, it resulted in a significant increase in output per man. Man hours per acre cleared averaged 4·6 hours for the 54 acres led into the tower, against 7·1 hours for the 29 acres ensiled in the clamp system—a fifty per cent improvement in labour utilization.

At High Mowthorpe, in the tower system, the use of the dump box, instead of self-unloading trailers, was preferred as a means of keeping capital machinery cost down, as it allowed tipping trailers already available

on the farm to be utilized. This had the effect of reducing the improvement in labour requirement to a much lower level than that recorded at Bridget's, as both systems required four men for efficient operation. The potential saving in labour was, however, illustrated by the reduction in the number of loads required to transport the high dry matter grass to the tower, averaging 2·3 loads per acre, compared to the figure of 3·9 loads per acre required to clear an acre of wilted grass in the clamp system.

It is impossible to generalize successfully about the relevance of these observed economies in labour to individual commercial farm situations. However, they did appear to be substantial and could lead to a reduction in the annual wages bill. At High Mowthorpe the need for four men to operate the dump box system would mean that the only saving would be in terms of overtime, but on farms adopting the forage box system, as at Bridget's, the reduction in team size at a peak period for labour demand could be the means of reducing the permanent farm staff by one or two men. Dispensing with one man alone would more than recoup the total extra annual capital charge for the tower system, which the N.A.A.S. found to vary from £597 for a 50–60 tons D.M. tower to £626 for one of a 200–240 ton D.M. capacity.

If the choice on a particular farm lies between towers and clamps, out of which the silage is cut and carried to the stock, a further saving in labour will be achieved by the use of the mechanical silo unloader. Totally-mechanized feeding, with conveyors carrying the silage to the cattle would save labour still further, but would entail an increased capital cost. However, it must be remembered that these savings in labour during the winter will result in overall increases in farm profits only if regular staff can be dispensed with or released for other profitable work, or if less overtime is worked. Furthermore, if the choice lies between towers and *self-fed* silage, only slight savings in labour resulting from the installation of the towers and their unloading equipment would be expected. However, wastage of silage at feeding might well be reduced.

Overall Conclusions

These experiments have suggested that, when grass is being wilted to the high D.M. level required for tower silage, the onset of bad weather can cause substantial losses of D.M. yield. These will offset the low level of loss in the tower and, consequently, the overall conservation efficiency of the tower system may not be greatly better than that achieved with clamps. This means that any increases in gross margin dependent upon the difference in conservation efficiency will be too small to recoup fully the extra capital invested in the tower system. However, it is important to remember that these trials were repeated over two seasons only. One of these, 1965, was characterized by particularly bad weather during silage making. If the ratio of one such bad year in two is not typical of a run of several years, the field losses with tower silage averaged over the two years may be unrealistically high. The only way of verifying this would be to keep records of field losses over several more years.

If, however, the adoption of a tower system can be the means of reducing the permanent farm staff, the saving in wages, plus any increases in gross margin achieved, will more than pay for the extra capital outlay.

Results at Bridget's and High Mowthorpe may appear to be in conflict with the experience of those commercial farmers who have made the change from clamps to towers and reported some substantial financial benefits. Numerous surveys and reports tend to confirm this view.

In the North, Addison and Joce in their report *Grass Silage Conservation and Storage in Clamp and Tower Silos* show tower silos to be more efficient. They calculated that towers should improve profits over wilted silage stored in clamps with herds of 80 cows or over. This calculation was confirmed by a N.A.A.S. Study Group in the south east of England who reviewed all available information. They further concluded that for beef production tower silos would be justified in enterprises of over 120 animals. In Yorkshire and Lancashire, a N.A.A.S. survey of dairy farmers who had recently changed from clamp to tower systems showed that the change was normally accompanied by a substantial improvement in the gross margin per cow. This may be partially due to a substantial saving in concentrate costs, thought to be due to the feeding of better silage than that previously available.

The Husbandry Farm results suggest that the better performance achieved with tower rather than clamp silage may not have been entirely due to any intrinsic superiority of tower silage, but was largely a result of farmers realizing that they would have to justify the extra capital cost involved in changing to a tower silage system by ensuring that the change was accompanied by general improvement in conservation and grassland management. On the two Husbandry Farms, true contemporary comparisons were made between cutting the same grass at the same time and putting it in the two types of silos.

The grass was cut young and both silages were therefore of high feeding value, and it is possible that the care taken in ensuring good fermentation in the clamps was greater than that normally given under commercial conditions.

Under the pressures of commercial farming it may be that a tower silage system is easier to operate successfully than clamp silage. The ease with which successive small cuts can be stored without excessive wastage means that grass can be cut earlier and more frequently, thus providing better silage and better aftermaths for grazing.

The trials at the two farms do, however, show that the great potential improvement that tower silos can bring will not always be realized. Weather conditions at the time of cutting, wilting and filling will have an important bearing on efficiency. In the drier areas the chance of achieving satisfactory wilting without excessive field loss will be greater than under high rainfall conditions. Each individual must, therefore, assess his own chance of regularly achieving satisfactory wilting before considering a change to tower silos.

NITROGEN AND STOCKING RATES FOR GRAZING BEEF CATTLE

S. C. Meadowcroft, *High Mowthorpe Experimental Husbandry Farm*

With semi-intensive beef rearing, in common with all other systems of livestock production based on grass, high output per acre can contribute to increased profit. The use of high nitrogen rates to promote lavish grass growth, and the successful management of animals at high stocking rates, appear to be the means of achieving this aim. However, there is a lack of reliable information upon which to determine the most profitable combination of nitrogen usage and stocking rate.

In order to provide this information, trials were started in 1965 at High Mowthorpe, Rosemaund and Trawscoed E.H.Fs. They were planned in co-operation with the Grassland Research Institute and were based upon a design evolved there. The essential feature of each trial was the comparison of three nitrogen rates, with three stocking rates within each nitrogen rate, according to the following pattern:

Units N per acre	Relative stocking rates (Ratios)				
50	1	1½	2	—	—
175	—	1½	2	2½	—
300	—	—	2	2½	3

The actual stocking rates at each E.H.F. in terms of beasts per acre were arrived at by multiplying all the above ratios by a common factor for the trial concerned. This factor was varied from farm to farm to allow for differences in average age and size of beast grazed, and in the estimated grass-growing capacity in the different localities. Thus the stocking rates compared ranged from 1·0 to 3·0 at Trawscoed, 1·2 to 3·6 at High Mowthorpe and 1·67 to 5·00 at Rosemaund. Hereford × Friesian steers were used at High Mowthorpe and Rosemaund, weighing 390 to 430 lb when turned out at 7 months old. At Trawscoed, Hereford × Friesian and Hereford × Shorthorn heifers were grazed. These were 12 months old and weighed 500 lb at turn-out.

The 50 units rate of nitrogen was applied in two equal dressings, whereas the two higher rates were each split into 6 dressings per season. Phosphate and potash were applied at standard rates of 25 per cent above the normal usage for each farm, irrespective of nitrogen level, with an additional dressing on paddocks cut for conservation.

The nine groups of 4 or 5 animals in each experiment grazed their own areas of grass (mostly young leys), after having been first turned out on to clean pasture elsewhere to become accustomed to grazing. Each group occupied the same ground from year to year. Each area consisted of 6 paddocks, 2 of which were shut up at the start of the season and cut for conservation before the end of May. The remaining 4 paddocks were shut up later for cutting in sequence before the end of July. Throughout the season the cattle grazed the paddocks available to them rotationally, no supplementary feed being given. In order to simulate good grazing practice, i.e., to ensure that highly digestible herbage was available at each grazing while avoiding

grazing too tightly, all nine groups of beasts in each experiment were moved from paddock to paddock simultaneously at $3\frac{1}{2}$ day intervals. In the first part of the season any surplus grass left after grazing was removed in the conservation cuts, while in the second half topping was carried out. These methods ensured that subjective bias in the management of the experiments was reduced to the minimum while maintaining a high standard of management.

Preventive veterinary treatment was confined to vaccination against husk before turn-out. Where the appearance of the beasts and faecal worm egg counts indicated that worm burden could be affecting their progress, all beasts were dosed with an anthelmintic.

Results

Changes in the grass swards

Examinations have been made annually at each farm and it is clear that the methods of grassland management employed have encouraged the persistence of the sown species in leys. Most paddocks contained 70–90 per cent of sown grasses and clovers in the third year of the trial.

In the third year, swards which received 50 units N per acre averaged 28 per cent ground cover by clover, compared to 7 per cent and 2 per cent in swards which received 175 and 300 units N per acre respectively. There have been no other significant effects of treatments on sward composition.

Health of stock at grass

With the exception of the 1965 season at Rosemaund, health has been excellent. Of the 333 beasts involved (excluding Rosemaund in 1965) only 3 were replaced at grass for reasons of poor health. There has been no indication that the use of up to 300 units N per acre on the grassland during the season has been prejudicial to the health of the grazing cattle.

At all farms there has been some reluctance to graze the more heavily stocked paddocks from mid-season onwards and this was very noticeable at Rosemaund in 1965 when it was accompanied by scouring and led to the removal of 6 beasts from the plots. Veterinary investigations eliminated parasitic worms as a causal factor, but there was no positive diagnosis. Chemical analyses of herbage grazed by affected cattle have shown above-average levels of both non-protein nitrogen and nitrate nitrogen.

Total liveweight gains per acre at grass

At each stocking rate at which comparisons can be made, the use of an additional 125 units N per acre resulted in approximately 100 lb extra gain in live weight per acre.

Despite an adverse effect on individual liveweight gain, almost all increases in stocking density resulted in a higher total gain at grass. The one exception was the increase to the highest stocking rate attempted. This proved to be excessively high, in that individual liveweight gain was so depressed that the total gain per acre was below the maximum achieved.

The best total gains resulted from a combination of high nitrogen usage (300 units N per acre) and high (but not too high) stocking rate. With cattle turned out at 6 months old, the stocking rate which resulted in the highest gain was $3–3\frac{1}{3}$ beasts per acre and with cattle turned out as yearlings it was

2–3 beasts per acre. The best total gains achieved have been 851 lb per acre at Rosemaund and 839 lb per acre at High Mowthorpe.

Conservation

Herbage surplus to the needs of the grazing animals was conserved, and this amounted to approximately 1 ton of D.M. per acre from all treatments, equivalent to a silage cut taken from about half of the area of grass available to each group of cattle.

Individual liveweight gains at grass

The mean daily liveweight gains achieved by each treatment group during the three years at High Mowthorpe and Trawscoed and during the two years at Rosemaund are shown in the following table. The results of the first year (1965) at Rosemaund have been excluded because of the health problems previously discussed.

Liveweight gain per beast per day at grass (lb)

Units N per acre	Stocking rates (beasts per acre)				
High Mowthorpe (1965–67)	1·20	1·80	2·40	3·00	3·60
50	1·85	1·55	1·10		
175		1·82	1·49	1·20	
300			1·61	1·40	0·95
Trawscoed (1965–67)	1·00	1·50	2·00	2·50	3·00
50	1·84	1·52	1·41		
175		1·86	1·53	1·49	
300			2·00	1·64	1·37
Rosemaund (1966–67)	1·67	2·50	3·33	4·17	5·00
50	1·89	1·36	1·00		
175		1·66	1·28	0·90	
300			1·45	1·09	0·78

At each farm there have been seasonal effects on the rate of gain of the stock at grass, but (excepting Rosemaund in 1965) these have had little influence on the relative performance of the nine groups of cattle.

The effect of increased nitrogen usage (at any one level of stocking) has clearly been to improve individual progress at grass and therefore also total gain per acre. However, increased applications of nitrogen have not generally made possible increases in stocking rate without some fall in individual liveweight gain.

The results leave no doubt that the best individual gains at grass are made where animals are kept at a relatively light stocking rate. All increases of stocking intensity (at any common level of nitrogen application) have retarded the progress of the individual beasts. This limitation of liveweight gain caused by increasing stocking intensity has not been solely caused by a shortage of feed. Cattle turned into paddocks containing abundant leafy grass frequently refused to graze a proportion of the available herbage. This lowered intake occurred most frequently from mid-season onwards and has resulted in generally poor gains by animals in the more heavily-stocked paddocks in the second half of the season.

Practical implications of the results

In practice some of the individual gains achieved have been unacceptably low in that the cattle have not been heavy enough at the end of the grazing season to be readily fattened out of yards. Crossbred steers to be marketed at $8\frac{1}{2}$ cwts in early April should weigh 700 lb at yarding if a daily gain of 1·7 lb in yards is assumed. This means that the minimum acceptable liveweight gain at grass from these animals on the 18 month beef system is 1·5 lb per day. The High Mowthorpe and Rosemaund results show that beasts stocked at $2\frac{1}{2}$–$3\frac{1}{3}$ per acre on grass receiving 300 units N per acre achieved this daily increase and also produced a very high total liveweight gain per acre. This has been the best compromise between reasonable individual weight gains and high output per acre.

The problem of maintaining individual liveweight gains at higher levels of stocking remains. Observations have shown that this is a question of getting better utilization, from mid-season, of the ample herbage produced by heavy applications of nitrogen.

A second problem arises where cattle have been stocked at around 3 beasts per acre. Not only is the area available for conservation restricted but, because of their relatively poor condition at the end of the grazing season, a period of approximately one month extra is required to finish these animals in yards compared to beasts stocked at only 1 to $1\frac{1}{2}$ per acre. The result is that only 20–30 lb silage per beast per day is available for indoor finishing, whereas the type of beast used has been found to fatten most economically on 50 lb silage per day supplemented by a small concentrate ration as necessary.

Both these problems might be eased by the adoption of a system of management which restricts the beasts to a smaller proportion of the available area during the spring months, allowing a larger area to be conserved. This area would be available as fresh aftermath grazing from mid-season onwards. Changes in the pattern of nitrogen application might be necessary, but such improvements in grassland management offer virtually the only alternative to zero grazing as a means of achieving better utilization of herbage by beef animals on their own*. This better utilization is essential if satisfactory individual liveweight gains are to be made by cattle at a high density of stocking.

*See the articles on mixed stocking with beef cattle and sheep on page 88.

A COMPARISON OF THE N.A.A.S. BLUEPRINT WITH A TRADITIONAL METHOD FOR GROWING EARLY TOMATOES

Derek R. Smith, *Efford Experimental Horticulture Station*

In a series of replicated experiments with early tomatoes carried out at Efford over a ten-year period, a variety of aspects of production have been examined. A great part of the early work in connection with environmental

control was done in co-operation with the National Institute of Agricultural Engineering. Related trials at the Lee Valley and Fairfield Experimental Horticulture Stations have also provided much evidence of the improvements possible in the production of early crops of tomatoes. Among the subjects studied are comparisons of suitable varieties—particularly those raised at the Glasshouse Crops Research Institute—and investigations into propagation techniques, irrigation, the most suitable stage at which to plant and, in particular, night and day temperatures and CO_2 enrichment. All these factors and others have been incorporated in a cultural 'blueprint' or 'prescription', which can be followed right through the season, with little or no need for amendment.

Because of the limited number of glasshouses available, it was possible to examine only one or two factors at a time in sufficient detail to give results which could be analysed. In 1967, however, a demonstration was mounted at Efford, combining all the best techniques in a single crop, for the purpose of evaluating the advances made in the cultivation of early tomatoes. For this demonstration, two similar and adjoining one-tenth acre, north/south orientated timber glasshouses, twelve years old, were used to grow a 'blueprint' and a 'traditional' crop. In both cases, seed of Eurocross BB was sown at 65°F (18·3°C) on 11 November 1966 and seedlings were pricked out ten days later.

The Blueprint Method

Day and night heating thermostats and a ventilating thermostat, housed in an N.I.A.E. aspirated screen in the middle of the glasshouse, were set to maintain the then current temperature recommendations:

Table 1

Stage of Growth	Positive temperature				Ventilating temperature	
	Night		Day			
	°F	°C	°F	°C	°F	°C
Pricking out—first truss buds just visible in head of plant (standing out time)	58	14·4	64	17·8	74	23·3
Visible bud—50% of plants with first flower open (planting time)	60	15·6	64	17·8	74	23·3
50% first flower—7 weeks after start of picking	62	16·7	68	20·0	74	23·3
Seven weeks after start of picking—end of cropping	62	16·7	64	17·8	70	21·1

(In the light of more recent knowledge, this temperature regime has since been modified in the latest edition of the blueprint, copies of which can be obtained from N.A.A.S. County Advisers.)

Temperatures were switched ½-hour after sunrise and ½-hour before sunset. Seedlings were pricked out into $4\frac{1}{4}$-in. wide-base whalehide containers in an east/west propagating house, at which time threefold CO_2

enrichment began and was continued until mid-May. The gas was distributed from ½-in. polythene lay-flat tubes at bench level in the propagating house, and at ground level in the growing house, between sunrise and 1½ hours before sunset daily. It was automatically cut off while ventilators were open. Seedlings were first stood pot thick on 1-in. mesh wire benches, and then spaced to 7 × 7½ in. on 9 December. Plants reached the visible bud stage on 23 December, and were then stood at their planting distances on tiles placed on the floor of the growing house. It was not until after this that the leaves of adjoining plants were allowed, of necessity, to overlap.

The Efford fertilizer concentrate consisted of 6·8 lb ammonium nitrate, 18·4 lb potassium nitrate and 5·3 lb magnesium sulphate, dissolved in 10 gal of warm water. It was added to all irrigation water from the fifth true leaf stage onwards, being diluted to 1 : 300 before planting (to give 170 p.p.m. of nitrogen, 270 p.p.m. of potash and 18 p.p.m. of magnesium) and to 1 : 200 after planting.

Planting at the rate of 13,440 plants per acre was done on 19 January, a month after standing out. The whalehide pots were not removed but split down the seam to facilitate rooting out, and buried. After ball watering to settle the soil around each plant, routine watering, using the N.A.A.S. calculated figure, began a week later. Overhead damping from spraylines was done up to four times daily but plants were never left wet at nightfall. The glass was not shaded at any time.

Training was done up hemp twine, and the method of taking stems up and over the paths was modified to allow them over the double rows, thus leaving the pathways unshaded by foliage. Since over 30 trusses set during the season, the plants were twice trained over the roof wires.

The Traditional Method

This varied from the blueprint method *only* in these respects:

plants were propagated in a north/south glasshouse;

pricking out was done into 3½ in. wide-base whalehide containers;

there was no CO_2 enrichment;

plants were spaced at 10 in. square in the propagating house, resulting in overcrowding, and were stood out only 11 days before planting on 6 February;

a single heating thermostat was set for 58°F (14·4°C), and a ventilating thermostat set for 68°F (20°C).

The Effects of the Cultural Treatments

The photographs on Plate V show growth differences which had occurred (1) when the blueprint crop was planted, and (2) when the traditional crop was planted, at which time the blueprint plants were three trusses ahead. Picking of the blueprint crop began on 20 March and of the traditional crop on 10 April. The photographs show both crops on 14 April, when (3) the third truss was being picked and the sixth truss was full-size on the blueprint plants, while (4) only the third truss was full-size on the traditional plants. Differences in growth were soon reflected in the assessed total weight in tons per acre and gross market value to the nearest £100 per acre, as Table 2 shows.

TABLE 2

Picked until:	Yield in tons per acre			Value in £ per acre		
	Traditional	Blueprint	Advantage of blueprint	Traditional	Blueprint	Advantage of blueprint
31 March	—	2·5	2·5	—	900	900
28 April	3·3	18·1	14·8	900	5,900	5,000
31 May	20·6	36·7	16·1	4,500	10,200	5,700
30 June	41·0	50·6	9·6	8,200	12,800	4,600
31 July	55·8	62·5	6·7	10,500	14,700	4,200
1 September	67·1	71·9	4·8	11,800	15,800	4,000
28 September	71·8	79·4	7·6	12,200	16,300	4,100
2 November	77·9	87·9	10·0	12,600	17,000	4,400

Not only was early yield heavier from the blueprint plants, but its quality was very much better. The first three trusses on the majority of the traditional plants, growing at too low a minimum temperature, either failed to set or, if they did set, developed slowly, and the quality of the fruit was poor. These differences are borne out by the higher value per ton of the blueprint crop, as well as by the higher value per acre, which reached its maximum of £5,700 at the end of May. By the end of October this advantage was less, but it was still £4,400 per acre.

Against the increased value of the blueprint crop must be set the extra cost of the improved cultural methods necessary to achieve it. An estimation, for example, of the cost of extra spacing, less readily arrived at than the major increases in the cost of fuel and CO_2, has yet to be made. Using 200-second oil, giving 175,000 B.t.u. per gal, costing 9*d.* per gal, and with a boiler efficiency of 70 per cent, the calculated increase in heating cost was £800 per acre. Assuming a price of 3*d.* per lb for CO_2 used at 50 lb per acre per hour, the cost of enrichment was £800 per acre. Replacing $3\frac{1}{2}$-in. wide-base whalehide containers with $4\frac{1}{4}$-in. cost £16 per acre more, while the additional compost to fill them was £32 per acre more.

By the end of April, the £5,000 increase in the gross market return per acre of the blueprint crop was more than three times that of the £1,648 per acre increase in direct costs detailed above. This was achieved without the need for day-to-day cultural decisions, almost all of these having been made and incorporated into the blueprint prepared before sowing.

DESSERT APPLES: THE REGULATED HEDGE SYSTEM

E. Gunn, *Efford Experimental Horticulture Station*

The majority of dessert apple trees in commercial orchards in this country are grown as bush trees. They are usually planted to give 100–150 trees per acre pruned relatively hard in the early years to form the main framework of the tree, and this is followed by either renewal or regulated pruning. These

orchards generally come into cropping in five to seven years and should be in their prime from the fifteenth to twenty-fifth years.

The main disadvantage of this system is the relatively long time taken to come into cropping and the slow build-up to maximum production. In addition, this type of tree does not lend itself easily to mechanical aids and much of the picking, pruning and other operations have to be carried out from ladders. It has been recognized for a long time that there would be advantages in planting orchards which come into cropping quickly, with the maximum height of the trees limited, so that most of the operations can be carried out from the ground or from a low mobile platform. However, in order to achieve this, the trees must be planted close together so that the branches effectively use all the space within the row, from the ground level upwards. Although such intensive plantations have been established in the past, many of these involved high initial costs and proved difficult to manage, especially for controlling vigour of the trees and weeds within the row. It was therefore extremely difficult to show any real advantage over more extensive systems.

With the advent of safe herbicides and economic pressures for a quicker return on capital, there has been a renewed interest in closer planting. In 1961 a one acre orchard was established at Efford as a pilot scheme, to see whether it was possible to evolve a system whereby early yields could be obtained while avoiding the heavy costs associated with many of the more intensive systems.

Three early varieties were chosen, Exeter Cross, George Cave and Stark's Earliest all on MM 104 rootstock and were planted at 18 × 10 ft, giving a total of 242 trees per acre. The trees were planted direct into an established sward, and were not staked, in order to provide information on the need for a support system. Subsequent pruning was kept to a minimum, only crossing and dominant shoots being removed. The trees were allowed to meet within the rows, and branches were only removed from the alleys if they interfered with the passage of machinery; the height of the trees has been limited to 8–9 ft. The sward has been cut frequently and a mulch applied along the rows in 1962 and 1964. After the first year, weeds within the row have been controlled by the use of herbicides; the area treated has been increased as the trees grew older, so that by 1966 the grass was confined to an 8 ft strip down the centre of the alleys.

Under this system, the growth on all varieties has been good, (Plate 00) but there have been some tree deaths due to wet autumns when conditions occurred in which trees on MM 104 are now known to be very susceptible to die-back and death. A number of trees were lost through wind damage and also some trees have leaned over and the fruit from these trees has been of poor quality.

Yields and Returns

'George Cave' has produced a far better yield and financial return than either of the other two varieties, emphasizing the importance of variety. As can be seen from the table, 'George Cave' came into cropping in the third year and reached a calculated 400 bushels per acre in 1966, six years after planting. The heaviest crop from 'Stark's Earliest' was 178 bushels per acre in 1965 and 'Exeter Cross' has still to produce any substantial quantity of

fruit. The poor prices obtained in 1965 and 1966 have also had a major effect on the plantation returns. The magnitude of this is reflected in the returns for 'Stark's Earliest' which, from 25 bushels in 1964, produced a net return half as much again as that from 144 bushels in 1966, though if anything the quality was better in 1966.

The blossom of all the varieties was severely damaged by frost in May 1967, which is clearly reflected in the yields, though to a certain extent this was compensated for by higher prices, especially with 'Stark's Earliest'. It is interesting to note that, despite the lack of crop, the trees did not produce too much vegetative growth and are still nicely balanced. There are no indications yet that there will be any problem in this respect, which of course is always a possible difficulty with intensive systems.

Expenditure and calculated yields and returns per acre, 1960–67
Variety: George Cave

Year	Yield—bushels/acre Total	Marketable	Value per acre £	Total expenditure £
1960–61				162
62				57
63	21	21	28	31
64	26	26	44	51
65	257	189	76	29
66	400	314	110	50
67	95	95	77	62
	799	645	£335	£442

The values are based on the gross return from the market, less all picking and marketing costs. These costs came to 6*s.* 0*d.* per bushel for the years 1963–65 and 8*s.* 0*d.* per bushel for 1966 and 1967.

Costs

Details of all costs have been kept and to the end of 1967 the growing and establishment costs amounted to a total of £442 for this one acre plantation, with an average annual expenditure, excluding harvesting costs, of £45. The greatest single cost has been for materials, including the initial cost of the trees which represents 48 per cent of the total expenditure. The use of machinery, including the operator, came next at 32 per cent and hand labour accounted for the remaining 20 per cent. These costs do not take into account value of the land, overheads, or depreciation. The annual expenditure is detailed in the table, which shows that for the past three years the income from 'George Cave' has been greater than the annual running costs. The total expenditure, however, still exceeds the total return, but the net deficit is already down to £107 per acre for 'George Cave', compared with £167 for 'Stark's Earliest' and £422 for 'Exeter Cross'.

Discussion

Although the performance of the trees under the system described is by no means ideal, the original concepts have been generally fulfilled. The trees have responded well, particularly to the light pruning in the early years; they

have been easy to manage and came into cropping quickly. Experience gained with this technique has shown the need for some modification, notably a different rootstock, as MM 104 would not now be recommended. Some simple method of staking and a greater use of herbicides in the early years, would also have been beneficial. The method has, however, produced an appreciably earlier return on capital than the traditional bush system, without any particular demands on management skills.

HERBICIDES ON SPRING SOWN BULB ONIONS

P. B. Tatham, *Efford Experimental Horticultural Station*
J. D. Whitwell, *Kirton Experimental Horticultural Station*

The effective control of weeds is probably the most important operation in the cultivation of onions. Onions are slow to germinate and up to ten weeks may elapse between sowing and the one true-leaf stage. During this time they are very susceptible to weed competition and any check to growth resulting from weeds, mechanical injury or the use of herbicides causes a reduction in final yield and a high proportion of thick-necked bulbs. Because of their upright habit of growth, onions do not form a leaf canopy which, in other crops, assists in smothering later weed growth, so that weeds must be controlled throughout the entire growing season which may be seven months or more.

Herbicides for use in onions must be capable of controlling weeds in the early stages of crop growth without damaging the onion seedlings. They must be sufficiencly persistent to cover the period between emergence and the 'post-crook' stage, and be able to control a wide range of weeds.

Experiments conducted at Kirton and Efford Experimental Horticulture Stations during 1966 and 1967 have been concerned both with testing herbicides for their safety on the crop and estimating their activity on weeds by recording the percentage weed cover of the treatments (Kirton) and measuring the relative weeding times (Efford) compared with the controls. Although the soils at Kirton and Efford differ, the results obtained with soil-acting residual herbicides at both centres are similar and consequently support the recommendations that are currently being made for weed control in this crop.

Pre-emergence Treatments

In seasons when weeds germinate ahead of the crop, paraquat can provide good early control by contact action, but more often than not onions and weeds germinate together making effective use of this herbicide difficult. This seasonal variation was apparent in the trials at Efford where in 1966 a good early control was achieved with paraquat, whereas in 1967 in contrast this material gave poor control due to delayed weed emergence. This variation in results confirms the limited usefulness of pre-emergence contact herbicides in this crop.

The residual herbicides that have been tested include propachlor and pyrazon plus chlorbufam, with chlorpropham as a standard for comparison. Propachlor 3·9 lb a.i. per acre (as 6 lb Ramrod) was applied shortly after drilling

at Efford and one week after drilling at Kirton. Although most experience shows onions to have a reasonable degree of tolerance to this herbicide, some damage, resulting in a reduced stand and lower final yield, occurred at Efford in 1967 when heavy rainfall soon after spraying brought the chemical into contact with the germinating seeds. A check to growth has also been observed at Kirton.

Pyrazon 1 lb plus chlorbufam 0·8 lb a.i. per acre (as 4 lb Alicep) was applied at both centres in the same manner as propachlor. This mixture is known to cause damage on light soils when rainfall immediately follows spraying. No damage has occurred at Kirton in two years of trials, but at Efford in 1967 rainfall after spraying resulted in a reduction in seedling stand and final yield.

Chlorpropham has been a standard pre-emergence treatment for some years. Onions have little tolerance to it, though there is evidence that it is safer if applied just before emergence, and soil type and rainfall have an important influence on its effect. At Kirton chlorpropham 1 lb a.i. per acre applied one week after drilling has consistently given a slight reduction in seedling stand compared with other treatments, but as it is a very effective herbicide over a wide range of weed species and also has the advantage of low cost per acre, it can be a useful material particularly where knotgrass and other *Polygonum* sp. resistant to other herbicides are known to occur.

The efficiency of weed control depends on the extent to which susceptible species occur. Propachlor is ineffective against knotgrass, black bindweed and redshank so that relative weeding times and weed densities must be related to the weed species present. At Kirton all residual pre-emergence treatments have given consistently good control (1 per cent cover compared with 40 per cent on hand weeded controls) until mid May. In terms of relative weeding time all treatments at Efford reduced the work content by 50–66 per cent as compared with the hand weeded controls.

The persistence of pre-emergence residual herbicides breaks down from 5–8 weeks after application. The rate of breakdown is influenced by rainfall and temperature. At Kirton where the crop is sown in mid-March, delaying application until 2–3 weeks after sowing has been found advantageous in extending the period of control until the critical loop and crook stages are past. All residual herbicides may be applied at any time between sowing and crop germination but because their contact effect is slight the timing of application must be related to the state of weed growth.

It has been shown at both Kirton and Efford that failure to spray early enough results in weeds not being controlled. In addition species not susceptible to the chosen herbicide escape. The inadequate persistence of the existing herbicides also allows later germinating species to survive. Most of these will be too advanced to be controlled by post-emergence sprays and work at both centres has demonstrated that they are best dealt with by hand-hoeing and tractor skimming in mid-May, as a preliminary to follow up post-emergence treatments.

Post-emergence Treatments

Propachlor and pyrazon plus chlorbufam can both be applied post-emergence. No additional damage resulted at Kirton when propachlor 3·9 lb a.i. was applied in late May when the crop has one to two true leaves. No damage has

occurred at Kirton or Efford when pyrazon 1·0 lb plus chlorbufam 0·8 a.i. per acre has been similarly used. Manufacturers recommendations allow the use of propachlor both pre- and post-emergence on the same crop so that two-stage weed control programmes can be carried out with this herbicide. At the moment the recommendation for pyrazon and chlorbufam is confined to a single treatment, either pre- or post-emergence.

In three years of trials at Kirton the use of post-emergence contact herbicides such as sodium monochloroacetate, desmetryne and prometryne has consistently given an unacceptable amount of damage. The susceptibility of the crop to the two latter materials is largely influenced by its condition stage of growth. Since the timing of applications must, to some extent, and depend on the stage of weed growth, which may not coincide with a suitable crop condition, these treatments remain unreliable and cannot be recommended.

Short Notes on Other Experimental Work

CULTIVATION SYSTEMS FOR MAINCROP POTATOES

R. H. Jarvis, *Terrington Experimental Husbandry Farm*

The cultivations carried out in maincrop potatoes after planting may have a considerable effect on the yield of the crop and, together with earlier cultivations, will have a marked influence on the efficiency with which the crop can be harvested mechanically. Trials at Terrington E.H.F. have shown that appreciable yield increases may result from changing the traditional system of post-planting cultivations, and that by a combination of appropriate pre-planting and post-planting cultivations a reduction in the number of clods in the ridge may be achieved.

When herbicides first became available for use in potatoes, work at Terrington showed that considerably higher yields could be obtained by their use rather than by following a traditional pattern of post-planting cultivations. This latter system has inevitably varied from year to year, but normally involves first the harrowing of the ridge left at planting to give an almost level surface, and subsequently a series of deep grubbing cultivations between the rows designed to produce tilth for the final ridging. Where a herbicide was used, post-planting cultivations were kept to the minimum needed to provide adequate cover over the setts. In some cases no cultivations at all were needed after the setts had been covered, and on the remaining occasions the necessary cultivation was done as soon as possible after planting and the herbicide applied to a 'stale' ridge just before the crop emerged. In another system which has been studied, the number and severity of post-planting cultivations were reduced to the minimum needed to give both an adequate ridge and satisfactory weed control without using a herbicide. Actual cultivations have varied from year to year even more than in the traditional system, but typically they have involved the use of a light chain-harrow, inter-row V-harrows and continental-type ridging bodies. Latterly the purchase of new equipment has enabled us to follow more closely the Dutch system of post-planting cultivations which in this context may again be considered as a 'reduced cultivation' system.

The yields given by these systems from 1963 to 1967 are shown in the table. In most cases the difference in total yield between plots where cultivations were reduced and those treated with herbicide was small, although both these treatments gave considerably higher yields than traditional cultivations. However the use of a herbicide usually gave an appreciably higher yield of saleable ware than reduced cultivations because of the greater weight of unsaleable green tubers which resulted from this latter treatment. This was least noticeable in 1966; Pentland Dell, the variety used in that year, is considerably less liable to produce a high number of green tubers than the others used in this series.

A second result of a change in the type of cultivations is frequently a reduction in the number of clods in the ridge. Traditionally clods in potato ridges were regarded with tolerance, if not even with a measure of affection.

Yields (tons per acre) 1962–67

Year and variety	Total			Saleable ware		
	Cultivations		Herbicide	Cultivations		Herbicide
	Traditional	Reduced		Traditional	Reduced	
1962						
King Edward	13·7	—	16·2	10·5	—	12·6
1963						
King Edward	13·0	14·1	14·1	10·7	11·5	11·9
1964						
King Edward	15·7	16·1	17·8	11·8	12·8	15·0
1964						
Pentland Crown	14·2	15·0	17·6	11·3	11·5	14·8
1965						
Pentland Crown	21·3	23·5(c)	23·0	16·7	17·8(c)	18·5
1966						
Pentland Dell	12·0	13·6(c)	14·3	8·9	10·5(c)	10·8
1967 (a)						
King Edward	16·1	15·9(c)	15·8	12·4	11·2(c)	12·4
1967 (b)						
King Edward	9·4	13·4(c)	14·0	6·2	7·8(c)	9·9

(a) Trial on silty loam; 2·3 per cent O.M., 29 per cent clay.
(b) Trial on silty clay loam; 2·6 per cent O.M., 36 per cent clay.
(c) Dutch type cultivations

This attitude has been completely reversed by the introduction of complete harvesters, for no simple solution has been found on these machines to the problem of separating clods from potatoes. A reduction in the number of clods in the ridge should reduce the demand for hand picking on the harvester, and may also lead to less damage to the crop, for with fewer clods less vigorous separating devices need be employed.

The expression 'clods in the ridge' needs to be defined more precisely before considering this topic further. It is the part of the ridge which contains the tubers which is important in this respect. Under a traditional system of cultivations the soil is worked to a considerable depth before planting. Except on the lightest soils it is only rarely possible to produce a fine tilth to this depth; usually the tines of the implement will break up the moist lower layers into lumps which will either remain there unchanged or, in a dry season, become clods. But because the soil has been loosened, some of the tubers at any rate will develop there, well below the setts. The harvester share must be set low enough to lift these tubers, and inevitably the number of clods lifted will be high, even if a clod-free ridge has been built over the setts. The expression 'clods in the ridge' must refer to clods above the lowest level at which tubers have developed.

The situation above contrasts strongly with that achieved in the Dutch system of potato cultivation. Seedbed cultivations are restricted to the depth of reasonably dry soil and, if necessary, planting is delayed until it is possible to obtain at least 4 in. of tilth, though 6 in. would usually be preferable. Below this depth the soil is left undisturbed. The seed is planted with at least 2 in. of tilth beneath it. Although crop roots will penetrate into the unworked layer, normally no tubers develop in it. If a clod-free ridge can then be built over the setts, the situation should be very favourable for

mechanical harvesting as deep digging by the harvester is not called for. A fairly wide range of implements is available for making a suitable ridge, ranging from V-harrows to inter-row rotary cultivators, each used in conjunction with continental-type ridging bodies. At Terrington in 1967 a Dutch-type system gave 113 clods larger than $1\frac{3}{8}$ in. per cwt of potatoes harvested on a silty loam and 107 on a silty clay loam, compared with 200 and 455 where cultivations had been of the traditional type. (There were approximately 500 tubers per cwt in the crop.) These in themselves represent worthwhile reductions, but should be capable of further improvement.

At present the Dutch system is not without its disadvantages in some English conditions. The problem of greening, which has already been mentioned, is sometimes very serious. There is some evidence that the problem is most acute on silt soils of low organic matter content. Certainly many farmers on the more organic soils appear to be little troubled by it. Wastage through greening may be reduced to a more acceptable level by choosing a suitable variety. The two most common English varieties, Majestic and King Edward, are both very liable to produce a high proportion of green tubers, while others, such as Record, Pentland Crown and Pentland Dell, normally give a much lower proportion.

The question also arises as to whether a clod-free ridge is in itself desirable in the English climate. It is often maintained that the surface of such a ridge will 'wash' badly under the influence of heavy summer or autumn rain, and that the washed surface will either dry into clods or, if wet weather continues, fail to break up on the harvester web. In either case the separation problem might become more rather than less acute. Here again the difficulty appears to be related to soil organic matter content, being much more pronounced when this is low. But on all soils it may be considerably alleviated by changing the standard of a 'clod-free ridge' to a 'ridge free from large clods'. The presence of clods up to an inch or so in diameter, even in considerable quantity, will in no way interfere with the efficient mechanical harvesting of ware potatoes, and ridges containing a reasonable porportion of aggregates of this type will be much more resistant to the washing action of heavy rain.

Although many aspects of the subject require further investigation, improvements in cultivation technique offer a reasonable solution to the problem of the efficient mechanical harvesting of maincrop potatoes.

MINIMUM CULTIVATIONS FOR CEREALS

J. E. Whybrew, *Drayton Experimental Husbandry Farm*

Long term trials have been under way at five E.H.F.s since 1964, on soil types ranging from light sand to heavy clay. Exploratory work started even earlier, in 1962, so that a certain amount of information has already accumulated, making this an appropriate time to consider the lessons learned so far and to speculate on possible future developments.

Trials

The long term trials have compared three methods of cereal growing, as follows:

the conventional method—ploughing followed by normal cultivations and drilling;

a limited cultivation system in which only the top two or three inches of soil are disturbed; and

direct drilling in which no disturbance of the soil, other than that caused by drilling, takes place.

Weed control in the latter two systems is largely dependent upon the use of sprays, notably paraquat.

In addition to these main treatments, the trials were originally designed to investigate the value of returning straw to the soil to provide a surface mulch. Other subsidiary comparisons give information on the nitrogenous manuring requirements of crops grown under different systems.

The start was a ley killed by paraquat and provision was made at most centres for a phased start spread over four years to eliminate any seasonal effects. Two rotations have been included in the trial, the first consisting of two consecutive winter wheat crops followed by continuous barley, and the second one being wheat, wheat, barley, barley, break crop, followed by a return to wheat. The type of break crop is left to the discretion of the the individual farm director but it is to be a crop capable of being combine harvested, such as beans, peas or rape.

Preliminary work tested the suitability of various machines to undertake the task of direct seeding but none proved entirely satisfactory and it was through the courtesy of I.C.I. Plant Protection Ltd., whose help is gratefully acknowledged, that two specially adapted 'slit' seeders were made available in time for the start of the trials.

These made an inauspicious start. Two centres suffered crop failures due to the hard dry conditions prevailing in the autumn of 1964, but the other three centres were drilled successfully. The trials settled down and have now been running for three years. In the course of their history various snags, some foreseen, some unforseen, have been encountered. As a result, alterations have already been made to the conduct of the trials and no doubt will continue to be made as further experience dictates. One example is the amount of couch which existed in the leys at the start of the trials. This has created a problem of control which so far has not been solved.

The first major alteration made to the trials was to abandon the original idea of comparing carting straw off with spreading it over the stubble after harvest. This was done because trash on the surface of the soil increased the difficulties of direct drilling with existing machinery.

The development of 'limited cultivation' techniques lends itself to a more widespread application of many conventional tillage implements. Seed can be broadcast and followed by a rotary cultivator or discing to incorporate it into the soil; rotary cultivation or chisel ploughing can be followed by drilling. These are examples of the technique and the breadth of choice available in this situation.

Results

The results have varied from year to year from centre to centre but the overall trend has been for the yields of direct drilled crops to be slightly lower than conventionally grown crops.

Work at Jeallot's Hill on direct drilling has suggested that the direct drilled crop responds to higher nitrogen levels better than the conventionally sown crop. However, the results obtained so far from the E.H.F. trials do not present a clear-cut picture of any need to increase nitrogen levels over and above those necessary for crops grown under normal cultivation systems.

One main problem which had been forseen was the mechanical one. This has attracted some attention from agricultural engineers, and the development of direct drills is proceeding along two distinct lines: the use of specially designed coulters which are dragged through the soil in a similar fashion to normal drill coulters (cutting a slit in the soil by traction) and the application of the rotary cultivator principle to cut a slit in the soil and depositing seed and fertilizer at the same time.

Both systems have had their successes under some conditions, particularly on light soils, but neither has provided the complete answer, and present machinery developments have limitations which are not going to be overcome quickly and easily. No doubt developments will take place which will improve the chances of a wider adoption of the direct drilling technique on the less tractable arable soils, but the present situation seems to be orientated towards its adoption on the more easily worked loams and sands.

The other problem as forseen was that of grassy weeds. The control of most broad leaved weeds is well understood and catered for at the present time, so that the major weed problems confronting the cereal grower of the sixties and seventies are wild oats, blackgrass, couch, creeping bent, rough stalked meadow grass and annual meadow grass. Successful chemical control is possible for the first two; and under conventional systems, control of the others is possible through a variety of tillage operations: bare fallow, stubble cleaning, repeated cultivations during crop-free periods, good ploughing, and so on. However, under minimal tillage or direct drilling systems, they pose a large unresolved problem. So far no really successful chemical control of couch or creeping bent has been found but it may not be too much to hope that, in the future, chemicals will be developed which will provide selective weed control for these two species growing in cereals. After all, it is not many years since chemical control of wild oats growing in cereals was considered impossible.

A careful watch has been kept on soil conditions on all the trials by the soil scientists of N.A.A.S. So far there has been little or no evidence of any change on the direct drilled plots. The only observation of note has been the development of a thin platey layer two inches down in one sandy soil site. This has not shown any signs of developing further, but the trials have been functioning for a relatively short period and changes in soil conditions may become apparent at a later stage. As far as pests and diseases are concerned, the situation seems to be one of normal behaviour, with one exception, that is slugs. The slit left by the coulters on direct drilled plots has, in some cases, provided slugs with any easy means of access to the sown grain with corresponding reductions in plant population and yields.

Trash also created a problem, since stubble residues tend to interfere with the successful operation of some of the present generation of direct drills, but this has been solved by burning straw after combining.

The question of crop contamination of self-set seed from the previous crop has also arisen because the surface of the soil is not inverted, and unless the shed seed germinates before stubble spraying, it can contaminate the next crop.

Observations on plant growth suggest that the rooting system of direct drilled crops is shallower than that of conventionally grown crops whose roots normally explore the whole plough depth. Expert opinions seem to differ on the implications of this observation, but from a practical point of view, yields do not seem to have suffered seriously as a result. However, it has aroused great interest and is obviously worthy of further investigation.

This then is the present state of affairs; further development of machinery and weed control techniques is needed before the adoption of direct drilling is possible on a wide range of soil types. This is especially so on the heavy clays, where the potential advantages of direct drilling (timeliness, a one-pass system, the amelioration of the top two or three inches of soil) could prove of great benefit.

Minimal tillage, on the other hand, in the form of chisel ploughing followed by drilling, or a two-bladed rotary cultivator fitted with a corn drill, may prove more satisfactory for the heavier soils.

If, as seems likely, dual purpose drills capable of working both in a normal seed bed and also in undisturbed soil are developed, then the way seems open for a more flexible and logical approach to the problem of cultivations for cereal growing.

WILD OATS IN CONTINUOUS BARLEY

E. R. Bullen, *Boxworth Experimental Husbandry Farm*

Wild oats are one of the major factors affecting cereal yields at Boxworth. In 1957, work commenced on studying cultural methods of controlling wild oats in a 'rotation' of continuous spring barley. This trial showed that, unless some means of control was adopted, the wild oat population increased to such extent that the phrase 'wild oat explosion' more than justified itself. From an initial population of one wild oat plant to 2 sq. yards, the weed density reached an average of 146 plants per sq. yard in eight years. However this figure conceals considerable differences due to the autumn cultural practices compared in the trial, as can be seen in Table 1.

TABLE 1

Wild oats per sq. yd. at harvest in 1964

	Straw	
	Burnt	Baled
No stubble cultivation	59·2	102·0
Shallow ploughed	146·7	152·7
Rotary cultivated	188·7	225·7

Most of the autumn cultural treatment affected the speed of this build-up, as can be seen in the table above. It was checked by burning the straw, compared to baling it; on the other hand it was accelerated where stubble cultivations were carred out. This result was unexpected, as the concept of encouraging seeds to chit when they can be killed by subsequent tillage is a well known method of weed control. Further, stubble breaking by rotary cultivator encouraged wild oats to build up faster than the shallow ploughing method also tested.

In an attempt to elucidate the reasons for this, areas of the undisturbed stubble were enclosed under cages. This showed that, where birds and rodents were excluded, there were, on average, five times as many wild oat seeds on the ground before ploughing in the normal way in December.

Bird gleaning was clearly one factor which could account for the removal of these seeds. Burying the seeds during stubble cultivation probably rendered them inaccessible to birds and, in view of their characteristic dormancy, did not encourage a worthwhile number to germinate.

In addition to the autumn treatments, there was one spring method of control tested. This was consistently successful in controlling wild oats. It can be termed the 'spring fallow' technique—in which a rough seedbed is prepared to encourage wild oats to chit, but the cereal is not sown until weed germination is virtually over. These seedlings can be killed during seedbed preparation. Using this method, wild oats were reduced to a very low level and after eight years there was only one plant to seven square yards of barley at harvest time.

In the spring of 1965 the trial was modified. Herbicides capable of selective control of wild oats in cereals had been available since 1957. One of these has been used in an attempt to clean up the infestation on the plots hitherto sown at the normal time. Each plot was split in two; one half has been late-sown using the 'spring fallow' technique and the other half has been early-sown with a post drilling application of triallate. Normal commercial recommendations for dosage and incorporation have been used.

Both methods have been successful. Barley yields have increased by 50 to over 100 per cent above the 1964 level, and the number of wild oats was dramatically reduced in the first season and has remained low (see Table 2).

TABLE 2

Effects of chemical and cultural treatments on numbers of wild oats and yields of barley

Barley crop	1964 8th	1965 9th		1965 10th		1967 11th	
Variety	Proctor untreated	Proctor		Impala		Impala	
		Sprayed	Late-drilled	Sprayed	Late-drilled	Sprayed	Late-drilled
Wild oats per sq. yd: in spring (seedlings)	—	—	383	—	77	—	26
at harvest	146	5·7	1·2	3·6	7·2	3·9	8·6
Barley cwt per acre	20·1	39·2	31·6	41·8	35·0	29·7	33·3

Although fewer seedlings have been recorded on the late drilled plots each spring, the number of wild oats at harvest has not shown a similar progressive rate of decline in the past two seasons. Even if the seed reservoir produced in the years up to and including 1964 becomes exhausted, the smaller amount of seed shed each year since is still sufficient to ensure that, despite some natural wastage, there is a potential threat of another wild oat build-up if control measures are relaxed.

The persistence of wild oats through dormant seeds together with seasonal differences in germination means that any evaluation of control measures or systems must be on a fairly long term basis. This trial is therefore being continued to see if it can reveal more about the dynamics of wild oat numbers under continuous spring barley cropping when chemical and cultural control measures are employed.

USE OF CHILLING AND PROPIONIC ACID IN GRAIN STORAGE

K. C. Morrison, *High Mowthorpe Experimental Husbandry Farm*

With the increase in cereal acreage, the situation is reached on many farms where existing drying capacity is insufficient to deal with incoming grain at a high moisture content. One way of spreading the load is to store grain in gas-tight tower silos or sealed polythene and butyl containers. Two additional alternative, or auxiliary, methods for conditioning moist grain are now available. Firstly, by chilling the grain mass using farm refrigeration equipment, secondly, by treating freshly harvested grain with propionic acid.

Chilling

The reduction of temperature required for safe storage is governed by the moisture content of the grain, the duration of storage, and whether the grain is to be used for seed or feed. The upper limit of moisture content of grain which can be economically stored, using commercial refrigeration equipment, is 22–23 per cent.

The practical aspects of grain chilling have been investigated at High Mowthorpe and Drayton since 1965, using 5 h.p. and 3 h.p. refrigeration equipment respectively.

At Drayton, comparisons were made of the chilling time required for two bins each of approximately 29 tons capacity, only one of which was insulated. In 1965, Champlein wheat, at 20 per cent M.C., was stored from early September until May. It was found that 40 per cent more chilling hours were required to maintain the required temperature in the non-insulated bin. For the 1966 harvest an additional fan was installed to increase the air-flow from 1000 c.f.m. to 1700 c.f.m. Two 29 ton bins of Champlein were chilled and stored from 29 August until 10 May, when the wheat, after drying, was sold at current market price. Electricity costs (calculated at 1½d. per kWh) were 2s. 8d. per ton for the insulated bin and 4s. 1d. per ton when no insulation was provided.

At High Mowthorpe, moist grain was chilled and stored on the concrete floor of an existing building, with inexpensive insulation of the interior of the asbestos roof. The storage capacity, with grain at 8 ft depth, is approximately 240 tons. Chilled air was blown through 'on-the-floor' hessian covered welded-mesh ducts, with recirculation of chilled air via a 2 ft diameter metal duct above the grain, leading back to the chiller unit.

In 1966 the storage area was divided into two 60 ton bins of barley and one of 120 tons of wheat, by means of portable wooden partitions. In 1967 the partitions were removed and all the grain, barley, was in a single mass of some 240 tons.

Moisture content of the grain when harvested in early September 1966 was approximately 18 per cent and initial grain temperature was 61°F (16°C). In 1967, moisture content of the barley varied from 17–21 per cent, and the mean grain temperature was 68°F (20°C) when harvested in August.

In 1966 initial chillings of about 35 hours duration per bin reduced temperatures to around 48°F (9°C), and subsequent occasional chillings further reduced the mean temperature to 41·9°F (5·5°C) by mid-December. No further chilling was required before the barley and wheat were sold in January, some of the barley being sold for malting. An average of 3·2 chilling hours per ton were required for the two 60 ton bins of barley, and 1·7 hours per ton for the 120 tons of wheat. This seemed to indicate that, in 1966, the chiller was more economically utilized when chilling a grain mass larger than 60 tons. Electricity costs (at 1½d. per kWh) amounted to 2s. 1½d. per ton for the barley, and 1s. 5d. per ton for the wheat.

In 1967 the duration of chilling required to reduce temperature to a mean of 42·3°F (5·7°C) was 3 hours per ton; electricity costs were rather higher than in 1966, at nearly 2s. 4d. per ton, but initial grain temperature was considerably higher, at 68°F (20°C). Power consumption, when calculated in relation to °F per ton reduction was in fact almost identical.

Conclusions

These investigations indicate that chilling moist grain at harvest can provide a satisfactory alternative to drying without subsequent deterioration of the grain. At Drayton and High Mowthorpe, using this method over the past two years, over 700 tons of grain, varying from 18–21 per cent moisture, have been stored. The technique was not, however, investigated at the upper limit of 22–23 per cent M.C., where costs are likely to be higher and difficulties greater.

It should be stressed that when grain temperature has been reduced, it is not stable. A reliable means of periodically checking temperatures throughout the grain mass is therefore essential.

The need for a drier on the farm is not necessarily eliminated by the use of chilling, but pressure on drying capacity at harvest can be usefully and, on occasion, vitally reduced.

Propionic Acid

Whilst chilling is aimed at creating temperatures at which harmful micro-organisms are inhibited, the effect of propionic acid is one of virtual sterilization, creating a medium in which microflora are practically eliminated.

Germinative capacity of the grain is also destroyed by use of propionic acid; its use is therefore limited to grain for feeding.

At High Mowthorpe in 1966, two levels of propionic acid, 1·25 per cent and 0·75 per cent by weight, were applied to freshly harvested Impala barley, at 20 per cent M.C. The acid was metered into an auger at the time of filling two 2-ton hardboard-lined bins. No deterioration or heating occurred during storage from September 1966 to August 1967. The possibility of propionic acid treated barley becoming contaminated with microflora when crimped and stored for feeding was also investigated. Samples of treated barley at 20 per cent M.C. were stored in polythene and hessian bags from January to September, after being crushed in a serrated roller mill. No deterioration had occurred when examinations were carried out by the Regional Bacteriologist in September 1967, eight months after crushing.

Treated and untreated barley, supplemented with protein/mineral pellets, was fed to three groups of store lambs. Those fed treated barley took a day or two to accept it readily, after which their performance, in terms of feed conversion, appeared to be slightly better than that of the lambs fed untreated barley.

In 1967, feeding barley of 30 per cent M.C. and 22 per cent M.C. (9 tons of each) was treated with 0·75 per cent and 0·5 per cent P.A. respectively, with the object of ascertaining the 'threshold' of moisture content in relation to P.A. level. Considerable heating occurred in part of the 30 per cent M.C. barley but examination by the Regional Bacteriologist on 22 November revealed no serious deterioration. The grain itself was free of moulds, but 8 per cent of husks showed infection with myceliated yeasts. Since November visible moulding has occurred and the area affected has been removed and weighed, amounting to 11½ cwt in a heap of 9½ tons. A pilot study, with more accurate control, has been set up to observe the spread of mould (if any) to undeteriorated grain from the same bin.

Storage of 22 per cent M.C. barley with 0·5 per cent P.A. appears to be entirely satisfactory to date, four months after harvest.

In addition to barley, spring beans at 24 per cent M.C. were treated with 1·0 per cent and 0·5 per cent P.A. and have stored satisfactorily in heaps of 2 tons.

Feeding trials are in progress using 30 per cent M.C. barley treated with 0·75 per cent P.A. to replace the normal barley ration fed to 10 month old Friesian steers; beans treated with 1·0 per cent P.A. are being fed to 3–6 month old calves, replacing the normal protein portion of their ration. Progress of the animals to date appears to be entirely satisfactory and the treated barley and beans were readily accepted.

At Drayton a trial is in progress testing levels of P.A. treatments at the following moisture contents:

% P.A.	% Moisture
0·33	21·2
0·44	21·0
0·55	23·0
0·66	22·8

Development of microflora was satisfactorily inhibited from the date of treatment, 18 August, until 10 October, when a 'hot-spot' at 71°F (21·7°C) was discovered in the 0·55 per cent P.A. bin; this was 10°F (5·5°C) higher

than in the remainder of the bin or the other three bins. Examination of samples from the warm area showed development of moulds. After the middle of October, however, the temperature of the affected area fell steadily and had nearly reverted to normal by the end of November.

Conclusions

Farm adoption of the propionic acid treatment of moist grain could result in instances of untreated or inadequately treated grain being incorporated in a mass of treated grain. The possible effects of this require further investigation. Whilst the relationship between moisture content and P.A. level required is not yet precisely defined, there are indications that treatment with 1 per cent propionic acid, properly applied, is adequate for moisture contents up to 30 per cent.

Because of the corrosive effect of propionic acid it may be necessary to treat metal and other surfaces with which treated grain comes in contact with some acid resistant material such as silicone. Application of propionic acid in ill-ventilated buildings is unpleasant. It is advisable to protect the skin and eyes from contact with the material and, if it is to be applied in circumstances where there is a danger of its being inhaled, a respirator should be worn.

At the time the experiments were conducted, propionic acid was not commercially available. It seems likely, however, that when propionic acid is marketed nationally, costs of grain treatment are likely to compare favourably with other storage techniques.

PRODUCTION OF S.48 TIMOTHY GRASS SEED

J. MacLeod, *Bridget's Experimental Husbandry Farm*

A recent trial at Bridget's studied the relation of row width, autumn defoliation, nitrogen rate and time of application to the yield and quality of S.48 Timothy seed. The plots were drilled in 3·5-in. rows or 21-in. rows. The defoliation treatment, in which the stubble was cut off by a forage harvester set as low as possible, was applied to the appropriate plots each autumn after the first harvest. Nitrogen was applied as 60 units per acre in early April or early May, 120 units per acre in April or May, or as 60 + 60 units per acre in April and May. Half the trial area was sown directly in the spring of 1962, given 10 units of nitrogen and 25 of phosphate and potash per acre, and a further forty units of nitrogen in the autumn. The 21-in. rows were drilled at 5 lb seed per acre, and the 3·5-in. rows at 6 lb per acre. The remaining half was undersown in 1963, when the cover crop had 3 cwt per acre of a 14:6:20 compound fertilizer and the ley a further forty units of nitrogen in the autumn. Neither half was harvested in its establishment year. Each spring 42 units of phosphate and 84 units of potash per acre were broadcast on all plots. Both of the trial areas were harvested for three seasons.

The plots were cut direct by combine harvester as early as possible in September to avoid shedding of seed. The combine was run with the concave set fairly close, at a low drum speed, with the wind cut down to a

minimum and the tailings return shut off. This stripped off the ripe seeds in their glumes from the timothy stalks leaving the unripe florets still attached. The bags of seed, still invested in their glumes, were collected off the combine and cold-air dried by a moisture extraction unit of the type used in barn hay driers. After two weeks the combine, fitted with a draper pick-up, rethrashed the windrows of timothy left by the initial cut. The drum and concave settings were adjusted to give the maximum separation of the remaining (now ripe) florets from the straw. The bags of seed, still invested in their glumes, were collected and dried by cold blowing as before. The material from both passes of the combine was thrashed and cleaned during the winter to provide the eventual yield of pure seed from each plot.

In 1965 the crop suffered from severe wind and rain prior to harvest, causing very considerable shedding of seed. This one season apart, the seed production potential of the crop did not decline over the trial period. The mean yield of cleaned dried seed was 2·83 cwt per acre from the 3·5-in. rows and 2·88 cwt per acre from the 21-in. rows. Although annual variation occurred, application of nitrogen in April or as a split dressing was slightly preferable to application in May, as shown by the following figures:

at the 60 units per acre level, April application yielded 2·57 cwt per acre of clean seed as against 2·42 cwt per acre for the May application;

at the 120 unit level, April application yielded 3·26 cwt per acre as against 3·18 cwt per acre for the May application;

the split dressing yielded 3·25 cwt per acre;

application of 120 units of N per acre significantly increased the yields of cleaned seed in all years as compared with 60 units: 120 units instead of 60 units gave 0·69 cwt per acre more seed in April and 0·66 cwt per acre more in May;

defoliation depressed the yield of seed; overall the decrease was 0·53 cwt of cleaned seed per acre.

SILAGE CUTTING AND AFTERMATH PRODUCTION

M. Hastings, *Liscombe Experimental Husbandry Farm*

Cutting the spring silage crop early, before many flower heads appear, is considered one of the tenets of the production of high quality silage. The crop is then more digestible than when cut later, and the aftermaths also appear to be more vigorous and persistent through the rest of the growing season.

This has been confirmed by two years' experimental work at Liscombe, near Dulverton, Somerset (altitude: 800–1200 feet; annual rainfall: 55 in.) where a study has been made of the effect of varying the date of cutting upon silage quality and aftermath production. Manuring was fairly extensive: silage crops were grown with 100 units nitrogen and their aftermaths received three dressings of 40 units of nitrogen, a total of 220 units of nitrogen during the whole grass growing season. Phosphate and potash were also applied whenever nitrogenous fertilizers were used, the annual rates per acre being 120 units of phosphate and 150 units of potash.

Three pastures, in good heart, ranging from 6 to 20 years old and derived

from Cockle Park type mixtures, were used. In previous years they had been fairly intensively grazed and cut for silage. This management had produced good quality perennial ryegrass/meadow grass/white clover swards. Plots from each pasture were cut for silage at weekly intervals during May and June and the aftermaths were cut at monthly intervals during the rest of the season until the end of September. Yields were expressed as dry matter of the herbage and the nutritive value of this dry matter was measured by a laboratory determination of the digestible organic matter in the dry matter (DOMD).

Results showed that the silage crop increased in yield during May and June by approximately 1–1·2 cwt of dry matter per day. A yield of 5–10 cwt per acre of dry matter at the beginning of May rose to a yield of 60–65 cwt per acre by the end of June. Against this rapid increase in yield of dry matter must be counted the loss in nutritive value which occurred. During May there was only a slight drop from 77 per cent DOMD at the beginning of the month to 70 per cent DOMD at the end, but then the value dropped rapidly to 55 per cent DOMD on 28 June. So it can be seen that, during May, the nutritive value drops by only 0·25 per cent per day but during June there is a more rapid decline of about 0·50 per cent DOMD per day.

In terms of feeding value, therefore, there is a strong case for cutting the crop early. The earliness of cutting must, of course, be tempered by considerations of yield. If both the yield of dry matter and the nutritive value are taken together, the yield of nutritive material can be calculated. In the present experiments it was found that the yield of nutritive material rose rapidly during May to some 30–35 cwt of digestible organic matter per acre by the end of the first week of June. This date represented the best compromise between nutritive value of the crop and the yield of nutritive material.

Turning now to aftermaths, a clear and repeatable pattern was found. The date of cutting the spring silage crop did not materially affect the nutritive quality of the aftermaths. None of them was as nutritious as early May grass, first aftermaths being 70 per cent DOMD and dropping slightly as the summer progressed to 68 per cent DOMD.

In considering the amount of nutritive material in the aftermaths a clear pattern was again obvious. The earlier the silage crop had been cut, the greater the yield of the following aftermaths. When all the aftermath cuts were added together it was quite obvious that cutting for silage during May reduced silage yield, but this was compensated for by an increase in aftermath yield. Delaying cutting for silage until well into June not only reduced the quality of the silage but also reduced the overall yield of nutrients.

In practice, the time of cutting the silage crop is dictated by a host of factors in addition to yield and nutritive value. The weather, the capacity of the machinery, the manpower and the acreage to be ensiled, are all going to influence the rate at which the crop can be cut and ensiled. Nevertheless, this study has given a quantitative guide to grassland management for conservation and aftermath production in the south-west and re-emphasizes the need to cut as early as possible to ensure both good quality silage and a succession of dense, rapidly growing aftermaths.

EFFECT OF SPRING GRAZING ON HAY DIGESTIBILITY

M. J. Strickland, *Great House Experimental Husbandry Farm*

In many areas of the country, particularly on sheep and dairy farms in the north, it is common practice to graze with stock in the spring before closing fields up for conservation. The effect of this early grazing is to delay the growth of grass so that, when the herbage is cut for hay or silage, it is less mature and stemmy than if no grazing had taken place. As a result, on any date for cutting for hay or silage, the quality of the fodder will be higher when made from the spring grazed grass. If the practice of spring grazing continues over a period of years, the whole sward develops into a later flowering one and this accounts for the high quality of hay made from Yorkshire Dales meadows.

At Great House, trials were started in 1966 to measure the effect of grazing in the spring on the quality of the following hay crop. Parts of various fields were closed to stock on different dates in the spring, and the quality of the hay off each area measured after cutting on the same day in the summer. Hay quality was measured in terms of DOMD digestibility using either wether sheep or the laboratory *in-vitro* technique. The dates for closing fields were the beginning of April (i.e., no spring grazing) late April to early May, and early to late May. The results of the first four experiments are given under the average dates of closure in the spring.

TABLE 1

Digestibility of hay following different spring management

Trial	Sward type	Spring grazing: type of stock	Date of last grazing in spring		
			1 April	2 May	21 May
1	7 year ley	Sheep (moderately grazed)	59	60	68
2	7 year ley	Sheep (moderately grazed)	52	56	61
3	Old meadow	Dairy cows	61	64	70
	Mean		57	60	66
			1 April	21 April	3 May
4	Old meadow	Sheep (moderately grazed)	53	54	56

The results show that grazing a field in the spring increased the digestibility of the succeeding hay crop, and the longer the period before closing fields to stock in the spring, the higher was the hay quality. It is also clear that grazing between 2 and 21 May had a much greater effect on digestibility than between 1 April and 2 or 3 May.

The experiment was repeated on four farms in the Yorkshire and Lancashire Region. Two sites were on low lying land in the Fylde and two on hill land in the Pennines. Cages measuring 6 × 3 ft were placed in the fields early in the season to represent the first date of closure. When stock was later removed from the fields, the cages were taken away. Results from the farm areas are shown in Table 2.

TABLE 2

Digestibility of hay following different sward management

Location	Sward type	Spring grazing: type of stock	Date of last grazing in spring	
			20 April	9 May
Fylde	Old meadow	Sheep (moderately stocked)	51	58
Fylde	3 year ley	Sheep (lightly stocked)	56	59
Skipton	Old meadow	Sheep (heavily stocked)	63	64
Skipton	Old meadow	Sheep (moderately stocked)	57	59
		Mean	57	60

Spring grazing again caused an increase in digestibility of the subsequent hay crop, but the effect was slightly greater in the low lying areas where growth started earlier in the spring.

Over a number of years, digestibility studies on hay and silage at Great House have shown that, for each one day's delay in cutting date, the digestibility of the herbage falls by approximately $\frac{1}{3}$ unit*. Using this result, the effect of delaying closing pastures to stock can be assessed. When spring grazing was finished on 21 May compared with 2 May (19 days earlier), the digestibility of the subsequent hay or silage crop was increased by 6 units. This increase could have been produced by cutting the crop a similar number of days earlier in the season (i.e., 18 days). However, both these grazings were terminated during the period of very active grass growth in May. When fields were closed to stock before the beginning of May, the effect on hay quality was less marked: digestibility was increased by only 3 units when grazing was stopped on 2 or 3 May, compared with 1 April (31 days earlier).

These findings can be used as practical guidance by farmers in similar situations to Great House, as follows. Before 1 May, postponing the closing of pastures to stock by three days is equivalent to bringing forward the date of cut by only one day, in its effect on the digestibility of the hay crop. After 1 May the benefit of delayed shutting-up is much greater: only one day's delay is needed to equal the effect of one day's earlier cutting. So although the delaying of closing fields to stock in the spring is a sheer necessity in certain seasons simply to provide enough grazing, this can have a practical benefit in that the quality of hay made later in the season will be higher, if cut at the normal date.

In order to relate the results of the digestibility studies to changes in sward composition, several swards were subdivided into individual grasses. Poa species and other indigenous grasses formed a large proportion of the weight of each sward and also of digestible nutrients, since their digestibilities compared favourably with those of perennial ryegrass and other sown species. The effect of spring grazing is shown in Table 3.

*This value is very similar to the studies recorded at Liscombe E.H. Farm in Somerset. See previous article by M. Hastings.

TABLE 3

Change in sward characteristics

	Timothy	Meadow fescue	Poa species
Percentage of sward by weight:			
No spring grazing	52	35	13
Grazing until 19 May	42	18	40
Digestibility of grasses:			
No spring grazing	60	58	59
Grazing until 19 May	69	64	69

Grazing in spring increased the percentage of Poa mainly at the expense of Meadow fescue. The higher digestibility of the spring grazed sward resulted more from an increase in digestibility of the individual grasses than from a change in their relative proportion.

VACUUM-COMPRESSED SILAGE

G. D. Badger, *Drayton Experimental Husbandry Farm*

A series of trials begun at Drayton and Liscombe E.H.F.s in 1965 to compare vacuum-compressed with conventionally made bunker silage were continued in 1966/67. The vacuum method was also tested at Great House E.H.F. but without a comparison with the normal method.

The 1965/66 trials indicated that invisible in-silo losses were similar in the two types of silos, but visible losses were greatly reduced with both methods when the polythene (which was also used for covering the bunker silo) was kept in close contact with the silage by weighting. The 1966/67 trials have shown the vacuum method in a rather more favourable light, with non-visible losses as low as 16 per cent in one case, but this is still a far cry from the claimed figure of 5 per cent which first attracted attention to the vacuum method. However, a trial exploring the technique of intermittently adding small cuts to a vacuum silo has given encouraging results.

The results of the 1966/67 experiments are given below.

SINGLE CUTS IN SMALL SILOS

Liscombe

A wooden-walled bunker and a commercially available polythene vacuum pack were used. The herbage was cut from a perennial ryegrass/white clover ley which had been grazed by sheep in the spring. With both methods the herbage was cut from the same field and ensiled immediately, alternate loads going into each silo. Both were filled between 17–19 August. The vacuum silo was evacuated on the evening of the first and second days and again on 23 August, a vacuum of 18 in. mercury being achieved on each occasion. The conventional silo was lightly rolled each evening, and heavily

rolled prior to covering with polythene on 19 August. Subsequently straw bales were placed on top of the sheeting and a temporary tin roof erected. The vacuum silo was in the open but protected with an old polythene sheet which was kept in position by bags of fertilizer. 57 tons of fresh material was placed in each silo and the mean D.M. content was approximately 19 per cent in both. When the silos were opened on 1 December the conventional silo showed a small amount of waste chiefly at the open end of the stack. The vacuum showed no visible waste at all. Once the silos were opened the silage was removed as required, each load being weighed and sampled. A digestibility trial with sheep showed that the vacuum silage was superior (65 per cent digestible organic matter in the dry matter compared with 59 per cent) but the crude protein was slightly higher in the conventional silage. The silages were fed *ad lib*, supplemented with 3 lb barley per head per day, to Hereford × Friesian steers. The mean liveweight gain was 0·66 lb per day from the conventional and 0·81 lb per day from the vacuum silage, slightly more dry matter being consumed by animals fed on vacuum silage. The total losses were 35·8 per cent in the conventional silo compared with 22·4 per cent in the vacuum. The visible losses were 9·9 and 4·1 per cent respectively. In the previous season the total losses were 22 per cent and 23·5 per cent in the conventional and vacuum silos respectively.

Drayton

Particular attention was paid to wrapping polythene over and under the conventional silage, otherwise the experimental method was similar to that employed at Liscombe. The bunker used had concrete walls and was situated under a Dutch barn. The vacuum silo was also under cover and consisted of a commercially available polythene pack. The herbage was from a second-year perennial ryegrass/white clover ley cut on 21 May and allowed to wilt for 24 hours. The two silos were filled alternately. The conventional silo was lightly rolled between loads and again after filling. Four sheets of polythene were used for wrapping. There was one at either end, extending from three feet under the silage up on to the top surface, and there was one either side, extending from the base up the side walls. After filling, the two end sheets were taken towards the centre and then the side sheets were taken to overlap down the centre. The effect was rather like a parcel. Immediately afterwards a layer of straw bales was laid carefully over the whole silo. The vacuum silo was sealed and evacuated until a reading of 23 in. of mercury was shown on the gauge. Immediately after evacuation the silo was covered with a layer of straw bales. The whole operation was completed in one day. 25 tons of fresh material was put in each silo and the dry matter content was approximately 28 per cent.

The silos were opened on 25 November and the silage fed to matched groups each of 20 young steers. Both groups received in addition to silage, two pounds of concentrate per head per day. The trial ended on 5 January, 1967, and the mean liveweight gain per day was 1·4 for the conventional and 1·5 for the vacuum. Chemical analysis indicated that there had been a satisfactory fermentation with good acid development and there was little to choose between the two. The digestibility value was 69 per cent in the vacuum and 72 per cent in the conventional. Total in-silo losses were 26 per cent in the conventional and 23 per cent in the vacuum. Visible loss in the conventional amounted to 4 per cent compared to 7 per cent in the vacuum

but this latter figure was probably inflated due to rat damage to the polythene in the silo. Non-visible losses were 16 per cent in the vacuum compared with 22 per cent in the conventional.

Great House

Dry matter losses were studied in silage made in a commercially available vacuum silage polythene pack. The trial was not under cover and there was no conventionally-made silage for comparison. Approximately 28 tons of grass at 16 per cent dry matter were ensiled. The silo was filled, sealed and evacuated in one day and the following day it was again evacuated. Later the seal was broken periodically to draw off effluent. The total dry matter loss was 34 per cent compared with 26 per cent in the same trial in 1965. So the losses encountered in both years were far from being exceptionally low.

These trials at the three farms have suggested that, in spite of expectations that the vacuum technique would prove to be a particularly efficient method of conserving single small cuts of grass separately, careful exclusion of air from conventionally-made silage has produced similar results.

Adding Successive Small Cuts to a Vacuum Silo

It has been claimed that the vacuum method may be suitable for conserving successive small cuts of silage in the same silo. Preliminary trials in 1965, at Liscombe, indicated that it was possible to ensile additional material on several occasions during the season without layers of waste developing between the different cuts, and investigation of this aspect of vacuum silage was continued in 1966/67.

The herbage was from a perennial ryegrass/white clover mixture. The first cut was taken on 13 May and five cuts were taken in all, the last being on 22 August. Two silos, each containing 100 tons of fresh material at approximately 15 per cent dry matter, were filled and there were three cuts in each, the third cut being divided between the two silos. No wilting was attempted and molasses was added to all the herbage ensiled at the rate of 2 gal per ton of fresh material. After each opening the silo concerned was re-evacuated to 15 in. of mercury. When the final evacuation had been completed, each silo was covered with an additional polythene sheet which was held in position by bags of fertilizer. One silo was opened in October and the other in the following January. In each case there was no visible waste in any part of the silo.

The silage was fed without concentrate supplementation to two groups of four 12-month old steers, each load being weighed and sampled. Effluent was not recorded. The average total dry matter loss was 26 per cent, which compares favourably with losses recorded in vacuum silos where filling was completed in one operation. Further, the method enabled 32 tons of dry matter to be conserved from 11½ acres, with a digestibility value which varied from 67–71 per cent DOMD. The daily liveweight gain in the feeding trial was 1·3 lb per day from the first silo and 1·1 lb per day in the second.

This trial is being repeated in 1967/8 using slightly more mature herbage, wilted to give a silage of approximately 25 per cent dry matter with a digestibility value of 68 per cent.

HAY CONDITIONING

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Since C. Culpin wrote on *Equipment and methods for swath treatment of hay* in *Progress Report 1963*, trials have continued at Boxworth, Bridget's and Drayton Experimental Husbandry Farms. The object has been to keep pace with the developments in hay conditioning machinery. New principles of operation have been compared with existing methods, the aim being to speed the drying of hay in the swath, while attempting to keep yield losses to a minimum.

In the years 1963–67 inclusive, six trials were carried out at Drayton and one at Bridget's. The crops used were based on either perennial ryegrass or timothy/meadow fescue, with varying amounts of clover. Geographical factors, seasonal and other effects, resulted in herbage of different stages of maturity being cut. Dates of cutting ranged from 7 June to 4 July. The machines tested were the crimper, tedder (undershot and/or overshot) and some form of flail machine for conditioning, with the reciprocating knife mower or flail for cutting the crop. During the last two years a vertically-rotating multiple drum mower has also been tried out.

Time of First Tedding

In order to obtain information to support the almost universally-held view that the first tedding operation should take place immediately after mowing, a comparison was made for three years at Drayton between the first tedding immediately, and after a delay of twenty-four hours. In one experiment there was no difference in drying rate between the two treatments, and in two other trials an immediate tedding followed by another soon after (achieved by hitching a *two-row* tedder behind the mower) had an advantage over delayed tedding. In these two trials, by three days after cutting, immediate tedding had reduced moisture contents to 33·1 per cent and 47·4 per cent, compared with 35·4 per cent and 50·6 per cent respectively for the delayed tedding. These differences are small but they were consistent throughout the drying period. Sampling was not intensive enough to detect differences in evenness of drying, but this is probably a more important reason than merely increasing drying rate, for recommending immediate tedding.

Machines

Crimpers

The conclusions drawn at Drayton from earlier trials, reported by Culpin, were that there were insufficient advantages from repeated crimping to justify more than one pass. Crimping once only speeded-up the drying rate without any appreciable loss in yield, whereas crimping twice or more caused yield losses which offset the further improvements in drying rate. The use of the crimper continued to be investigated at Drayton from 1963 onwards and

*Previously at Drayton Experimental Husbandry Farm.

was used for one pass only, immediately after cutting with a knife mower. As previously, this resulted in more rapid drying than where the crimper was not used and the herbage was only tedded. At baling two to four days after cutting, crimped herbage achieved moisture contents 3–7 per cent lower than uncrimped herbage and this gain was not accompanied by any significant reductions in yield.

Flail Forage Harvesters

Prior to 1963, work at Bridget's and Drayton had shown that cutting with a forage harvester produced the most dramatic gains in drying speed compared with other methods of swath conditioning, but that this was usually accompanied by very serious losses in dry matter yield.

The experiment at Bridget's in 1963 was undertaken partly to find out whether these losses could be reduced by adopting an entirely new technique of operating the forage harvester. The aim was to lacerate the grass to the maximum and to lay it gently down on to the top of the stubble in a wide shallow layer, using a specially made deflector. This would promote a fast drying rate without the need to ted or turn the swath until it was rowed-up with a finger-wheel side rake for baling. It was hoped that losses in dry matter yield might be reduced by the avoidance of handling the crop between cutting and baling, but in fact it was found that no improvement was achieved. The drying rate was very fast, but the dry matter yield loss from cutting to baling was 26 per cent, compared with 17 per cent produced by cutting with a knife mower, followed by crimping twice and conventional tedding. A further disadvantage was the very slow rate of work resulting from the need to drive in a low tractor gear to achieve the intended drastic laceration of the crop.

This experiment also investigated the use of a double-chop forage harvester for cutting and for tedding once after cutting with a mower, a conventional tedder being used for subsequent operations in both cases. The action of this type of forage harvester *appeared* to be more gentle than that of a simple flail machine, because the flails of the former are designed primarily to cut rather than to lacerate (when silage making with this type of machine, chopping is achieved by a rotary cutter separate from the flails. When used for hay-making, the lid over the flails is opened to allow the cut grass to fall directly on to the ground, thus by-passing the chopping mechanism). In this trial, however, when used for cutting or tedding the machine performed in much the same way as other forage harvesters, giving good drying rates, but resulting in 24–30 per cent losses from cutting to baling compared with the 17 per cent given by knife-mowing and crimping. It did have a very respectable rate of work, however, and was later found to be effective for cutting laid and tangled crops. There are circumstances when the fairly heavy losses in yield caused by such machines can be tolerated if the gains in terms of quality of product achieved by increasing drying speeds, and hence diminished weather risks, are taken into account.

Flail Mowers

The flail mower, being a development of the flail harvester for cutting grass, might be expected to be better than the latter in some respects. The most important of these is in reduction of dry matter loss, as found in experiments at Drayton.

Used as the sole machine for both cutting and conditioning, drying rate was similar to, or a little faster than, where herbage was cut with a knife mower, crimped once and tedded. In one experiment there was little difference in yield between these two treatments; in another the flail mower gave a reduced yield of dry matter but left a stubble 30 per cent longer than the knife mower. Where a flail mower was used for cutting and the swaths were then tedded with a conventional tedder, drying rate was slightly better than that of swaths cut with a knife mower, crimped once and tedded. However, dry matter yield was considerably reduced following the flail, although stubble lengths on all treatments were similar.

Comparisons

From these results it would appear that, of the flail machines, the flail mower is better for haymaking that the flail forage harvester. Provided the flail mower is used as the sole conditioning machine or in conjunction with a swath turner rather than a tedder, drying rate is as good as or better than that of herbage cut with a knife mower, crimped and tedded, and yield may be little lower.

Another point about the flail mower is that in three trials out of four, it had a slower rate of work than conventional machinery. A knife mower covered up to 100 per cent more acres per hour than the flail mower used for cutting. A two-row tedder also covered up to 100 per cent more acres per hour than the flail mower tedding. Much depends on weight of crop and the foregoing figures are based on crops yielding 40–50 cwt per acre of dry matter.

When purchasing haymaking machinery and the advantages and disadvantages of one system or another are weighed, the question of cost looms large. Conventional systems may involve a reciprocating knife mower, a crimper and a tedder, in addition to a swath turner. Starting with no machinery at all, the cost of a flail mower and swath turner, perhaps £340 and £100 respectively, would be considerably less than for all the machines in the conventional system. Typical prices are £112 mower, £280 crimper or crusher, £240 tedder and £100 turner. However, the flail mower needs a more powerful tractor than is required by any of the other implements. A change in tractor size may necessitate changes in other farm implements or machinery if that tractor is to be utilized efficiently. On the other hand, a single implement (flail mower) will probably take less time annually to maintain than a knife mower, a crimper and a tedder.

Where some haymaking machinery is already available on the farm the choice of additional equipment may be less difficult.

The multiple-drum rotary mower

There is no evidence from the two trials (in one year) in which it was used that this machine gave any advantages in drying rate or yield. However, it did appear to have other advantages such as robustness, ability to deal with laid crops etc., which will continue to be assessed in further trials.

CALF REARING

A. H. Adamson, *N.A.A.S. Nutrition Chemist, Regional Headquarters, Leeds.*

Over the past few years a number of co-ordinated experiments on beef calf rearing have been carried out on the Experimental Husbandry Farms, and many of the results are also applicable to dairy heifer calves. Some experiments are still in progress, but it should soon be possible to suggest a scheme for the rearing of calves on an early weaning system based on the results obtained. The examination of milk substitute feeding has covered a comparison of high and low fat, various concentrations, warm and cold milk substitute, and a follow-up of the results from commercial organizations recommending once-a-day feeding. In addition, weaning at various dry concentrate intakes has been investigated, and also the composition of early weaning concentrates, in an effort to simplify and reduce the number of constituents.

Optimum Composition of Milk Substitutes

An experiment conducted on one intake of calves at High Mowthorpe and two intakes at Trawscoed compared the use of milk substitute with either a high (15 per cent) or low (5 per cent) fat fed twice per day at the rate of 1 lb of dry milk substitute per day re-constituted in 8, 6 or 4 pints of warm water. Early weaning concentrates, hay and water were offered to appetite and the calves were weaned when concentrate intake reached 2 lb per head per day. There were no significant differences between the treatment groups of calves during the 10 or 12 weeks of the experimental period in terms of liveweight gain (about 1·4 lb per day) total concentrate consumption (about 220 lb) or the time to weaning (4 to 5 weeks range for the three trials). No difference was detected between treatments at 6 months of age and there were no marked differences in health between treatments, although at High Mowthorpe there was a tendency for a higher incidence of scour on the high fat treatment. This could have been a chance occurrence.

Warm Versus Cold Milk Substitute

Boxworth, Bridget's, Great House, High Mowthorpe and Trawscoed have co-operated in investigating the feeding of 1 lb of milk substitute per day re-constituted in 6 pints of either warm or cold water. The warm milk substitute was fed at the usual temperature of about 100°F (37·8°C) and the cold milk substitute at calf pen temperature. This was attained by standing the milk substitute in the calf pens from the p.m. feed of one day until the a.m. and p.m. feeds of the following day. The same early weaning system was followed as for the experiment described above. The overall results indicated that on an early weaning system there was no significant difference in performance between calves fed either cold or warm milk substitute. Only at High Mowthorpe and Great House was any difficulty encountered in persuading calves to accept the cold milk substitute. For all centres and all treatments the mean liveweight gain from arrival to 12 weeks of age varied

from 1·20 to 1·43 lb per head per day and total concentrate consumption from 253 to 317 lb. The majority of calves were weaned between 29 and 40 days after arrival, but at High Mowthorpe calves averaged about 112 lb on arrival and were weaned within 21 days. Where calves were followed through to 24 weeks after arrival, the mean liveweight gain ranged from 1·32 to 1·42 lb for all centres and all treatments. Any differences were not significant.

Once Versus Twice A Day Feeding

Experiments are in progress at Gleadthorpe and High Mowthorpe in order to confirm the results obtained elsewhere, showing that there is no difference in performance between calves fed milk substitute once or twice each day on an early weaning system. Points of detail which may influence once a day feeding such as quantity of milk substitute and volume of liquid are also being examined. The results of a preliminary trial have shown no significant difference in performance between calves fed milk substitute once or twice a day. The results of further trials are not yet available.

Composition of Early Weaning Concentrates

Three trials at Gleadthorpe have examined the following four simple early weaning concentrate mixtures fed either as a meal or pelleted. Quantities are given in cwt:

	A	B	C	D
Rolled moist barley	18	16	16½	15½
White fish meal	2	—	1½	—
Soya bean meal	—	2	—	2
Linseed meal	—	2	—	—
Decorticated cotton meal	—	—	1½	2

All with Minerals and Vitamins

In the first trial mixtures A and B were compared. The mean daily liveweight gain for all treatments over the first 12 weeks was 1·67 lb per day and calves took an average of 28·5 days to be weaned, upon reaching a daily concentrate intake of 2 lb. 12 oz of milk substitute were fed per day, reconstituted in 6 pints of water. There were no significant differences between treatments except that the intake of meal A and nuts B was significantly greater than for nuts A and meal B preweaning.

In a second trial diets C and D were compared on the same lines as the first trial, but mean liveweight gain over the first 12 weeks was only 1·26 lb per day and it took 25·6 days to weaning. The only significant difference between treatments was the increased intake of nuts C, compared to meal C and meal D preweaning.

In a further trial a comparison of mixtures A and D was made, the treatments being superimposed on to once versus twice-a-day feeding of milk substitute. Results were similar to the previous trial, except that there were no significant differences.

A final trial has been carried out comparing simple mixture A and a complex concentrate in meal or pellet form. The complex mixture was made up as follows:

6 cwt flaked maize
4 oats
3 barley
2 Molassine meal
2½ soya bean meal
1 fish meal
1 linseed
Minerals and vitamins

The mean daily liveweight gain for all groups was 1·52 lb per head per day from arrival to 12 weeks of age but there was no significant difference between groups.

INTENSIVE YEARLING BEEF

J. M. Willcock, *Liscombe Experimental Husbandry Farm*

Much has been said about 'Barley Beef' following its explosive arrival on the farming scene in 1961. Preston, at the Rowett Research Institute, highlighted the possibilities of the system, which can give quick turnover without the use of land. In practice, financial success of the system depends upon moderately priced calves being grown rapidly, upon cheap concentrate rations and a low level of mortality. The choice of breed, the composition and preparation of the concentrate and the animal's previous management, all affect the important financial considerations of calf cost, food cost, conversion efficiency, killing out percentage and health. All these aspects have been under study at Boxworth, Gleadthorpe, High Mowthorpe, Liscombe, Rosemaund and Trawscoed Experimental Husbandry Farms.

In these trials calves were in most cases reared on an early weaning system from approximately a week old. A change over from an early weaning concentrate to a fattening ration containing approximately 85 per cent cereal plus 15 per cent protein supplement with vitamins and minerals was gradual. By between 12–14 weeks, when weighing around 200 lb, the calves had completely changed to the fattening ration. One of the hazards of a high concentrate feeding system is the occurrence of bloat, particularly during change over. This can be largely avoided by feeding some roughage, and in most of the trials carried out on the Farms a small quantity of hay or straw was fed.

Type of Animal

Because of availability and their high growth potential, Friesian calves have been used in many of the trials. Performance from change over to the fattening ration at approximately 12 weeks until slaughter at around 8 cwt live weight averaged 2·6 lb gain per day, ranging from 2·3 to 2·9 lb. Killing out percentage varied between 54 and 58. The proportion of fat to lean meat has been adequate, except in a few instances with certain dairy type calves when fat cover was lacking.

As expected, calves of the smaller Ayrshire breed took longer to reach 200 lb liveweight and change over to the fattening ration tended to take place slightly later at 14 weeks old. Daily liveweight gains from 14 weeks to

slaughter were 0·7 lb lower and killing out 3 per cent lower than with the Friesian. In some instances, in spite of marketing at the earliest possible weights to qualify for fatstock deficiency payments, carcasses carried too great a proportion of internal fat for present day requirements.

The number of trials in which the crossing sire was the Charolais were limited. From results available, liveweight gains and killing out percentage of calves out of Friesian and Shorthorn cows were similar to pure Friesians. Although inferior to the Friesian and Shorthorn crosses, calves produced by crossing Charolais with the Ayrshire and the Channel Island breeds made satisfactory performances and produced carcasses of acceptable quality.

Hereford cross Friesian calves made similar gains to pure Friesians, although there was a tendency for them to be in a finished condition before reaching adequate weight. This led to excessive fat in some instances.

Food Preparation and Substitution

The physical condition of food presented to livestock can affect the quantity eaten. Dry grain tends to disintegrate and become very dusty after rolling and mixing, but a trial in which rolled barley at 15, 18 and 24 per cent moisture content was fed in the concentrate mixture, liveweight gains were practically identical. No advantage in performance was gained from feeding rolled compared with kibbled barley, or from pelleting the concentrate mix compared with the mixture fed in meal form. However, in other trials, respiratory troubles have occurred and these were accentuated when the concentrate mix was in a dusty condition.

Most rations for intensive beef production are based on barley; under certain farming situations it may be more convenient to use other cereals. Investigations in substituting some or all the cereal part of the ration have been carried out. In a comparison between feeding the cereal constituent of the rations as all barley, half barley and half wheat, and all wheat, cattle made slightly better liveweight gains on the rations based on half and all wheat. Oats, when substituted for barley, led to slightly depressed gains and cattle tended to be less well finished on reaching slaughter weight.

Some saving in food cost resulted from reducing the quantity of protein supplement to half the usual rate with cattle from 6 months to slaughter.

In one trial with cattle of this age group, barley with minerals and vitamins gave as good results as a barley mix containing 15 per cent protein supplement. The use of urea as a cheap source of nitrogen to replace protein led to slightly poorer liveweight performance. One study suggests that the soya bean and fish meal in conventional barley beef rations can be replaced by rolled beans with satisfactory results.

Grass in an Intensive Yearling Beef System

Intensive feeding may be limited to the final fattening period only, and can quite successfully follow a period at grass. Spring born calves reared inside on an early weaning system, then turned out to grass, required from 10 to 15 cwt less concentrate to finish at similar weights as calves on an all concentrate system. Liveweight gain from yarding to slaughter has been similar to the corresponding period with calves on a fully intensive system. Even lightweight calves off grass at 3 cwt have been successfully finished by 13 months of age.

With single suckled calves, liveweight gains during the final intensive fattening period were 0·5 lb less than with calves on a fully intensive system. This in part was caused from the need to make a gradual change over from one system to another.

Conversion Rates

In these experiments the amount of food required from approximately 3 months to slaughter varied considerably: concentrate consumption varied from 28 to 42 cwt. This is as would be expected when dealing with a wide selection of breeds and crosses. Generally animals with the highest growth potential, namely the Friesians, Charolais cross Friesians and Charolais cross Shorthorns, were the most efficient converters. At the other end of the scale were the pure Ayrshires; with these, concentrates per lb liveweight gain ranged from 6·0 to 7·3 lb, as compared with 4·9 to 5·7 lb with Friesians.

Efficiency of conversion is, of course, closely related to the liveweight at slaughter. As the weight increases so the conversion rate widens. For example, to grow from 6 to 7 cwt liveweight, the concentrate requirement is approximately $6\frac{1}{2}$ cwt, but from 7 to 8 cwt liveweight, it is about $7\frac{1}{2}$ cwt. It is therefore important that, under a high concentrate feeding system, beasts be slaughtered at the minimum weight to qualify for fatstock guarantee, subject to satisfactory grading and killing out percentage. A well finished beast will reach the required minimum carcass weight when slaughtered at $7\frac{1}{4}$ cwt liveweight. It is as well, however, to work with a safety margin in case of a poor killing-out percentage and slaughter at $7\frac{1}{2}$ cwt liveweight would adequately cover this in practice. It can be seen that a cattle weighing machine is a useful item of equipment on farms where beef is produced under an intensive system.

Animal Health

Various ailments cropped up in the course of the trials. Bloat and respiratory troubles have already been mentioned. A few cases of barley poisoning occurred, particularly at a change of management such as when beasts came off grass. However, this has been avoided by a gradual change over to high concentrate rations. Some deaths were caused by Blackleg, which is a bacterial disease that can cause fatalities on some farms, especially under high plane feeding. Vaccination is advisable.

Financial Returns

Because land plays little or no part in an intensive yearling beef production, financial returns must be considered on a headage rather than an acreage basis. Returns varied from a gross margin of over £30 per head to a minus figure.

The main factors which affected financial results were: cost of calf, cost of feed, price of product, food conversion efficiency, liveweight gain, killing-out percentage and animal health problems. The first three are financial factors which can be controlled to some extent by buying calves when they are below the maximum seasonal price, by arranging that the period of highest concentrate consumption coincides with relatively low barley prices, and finishing animals when beef prices are moderately high.

Food conversion efficiency is clearly related to growth potential of calf and the state of husbandry. It is an important factor: a difference of 0·1 in conversion rate is equivalent to approximately $\frac{3}{4}$ cwt in food eaten, so choice of breed and slaughter weight must be carefully watched, as pointed out earlier. The importance of a high rate of liveweight gain is often insufficiently emphasized: with low rates of gain, beasts will take correspondingly longer to reach finished condition, which results in a lower total throughput of animals and hence less effective use of buildings and other fixed equipment. Killing-out percentage is important, because a difference of 2 per cent at a liveweight of 900 lb is equivalent to 18 lb of carcass meat. Choice of breed is important here, as suggested earlier. The various animal health problems that particularly affect intensive beef have also been discussed and the appropriate precautions indicated.

Results of the trials confirm that intensive yearling beef production can be a viable system. Returns can be high if the price of the basic materials is favourable. If, however, calf prices, feed prices or mortality are high, then margins per beast are likely to be low and any real impact of the system on Net Farm Income would need to be due to a large throughput.

METHODS OF PROCESSING GRAIN IN INTENSIVE BEEF FATTENING RATIONS

B. Horne, *Boxworth Experimental Husbandry Farm*

A grant from the Boreham Institute of Agricultural Engineering has provided facilities at Boxworth for investigations into the effects of different methods of feed grain processing upon the performance of cattle intensively fed to produce twelve months beef.

A pilot experiment, beginning in January 1967, consisted of a comparison of treating the barley component of an intensive beef ration by rolling or coarse grinding. The barley treated in this way had either been harvested moist and stored in sealed silos, or harvested dry and stored in conventional bins. The moist barley rations had an average moisture content of 20 per cent, and the dry $14\frac{1}{2}$ per cent. They were composed of $87\frac{1}{2}$ per cent barley on a dry matter basis with 10 per cent of a protein supplement of fishmeal and soya bean meal, plus minerals, vitamins and trace elements. Each of the four rations was fed individually *ad libitum* to six Friesian steers.

Processing

Rolled grain was processed by a conventional rolling mill with flat rollers. Pressure on the rollers was as severe as possible. A plate grinding mill was used for the coarse-ground barley, with the plates set fairly wide to produce the largest possible broken particle size.

Analyses of the processed grain conducted by the National Institute of Agricultural Engineering showed that rolling, as expected, produced an average particle size considerably larger than coarse grinding. In addition, up to 4 per cent of whole grains passed through the mill. Moist barley,

whether rolled or ground, resulted in a consistently larger proportion of coarse particles than when dry barley was used. In all cases the proportion of 'fines' was small.

As the summer progressed, and ambient temperatures rose, the moist-stored grain deteriorated markedly in quality, due to fungus development in store. The rations made from the moist barley were fusty and rank and, while the moulding appeared to have no actual ill effect on health, some animals refused food from time to time.

The principal fungi involved were: *Aspergillus fumigatus*—the 'farmers lung' fungus, also known to cause mycotic abortion in dairy cows; *A. candidus*, *Mucor* spp., also potentially harmful; and *Penicillium* ssp.

Digestibility of the Rations

The digestibility of the rations was determined by using the chromic oxide inert marker method. The chromic oxide was fed at a known concentration in each ration, and the resulting concentration in the dung measured. Visual evidence indicated that the dung contained differing amounts of undigested grain, according to ration type.

This was confirmed by separating whole grains and undigested grain particles from dung samples and recording the quantity present as weight of dry matter. It was found that, with both the dry and the moist barleys, rolling depressed digestibility by 2–4 per cent compared to grinding and that this drop was accompanied by a rise in the proportion of undigested grain in the dung (from 0·2–2·5 per cent, on average).

Animal Performance

Animals fed on the coarse ground rations tended to consume more dry matter per day than those fed on the rolled rations, and had a correspondingly higher liveweight gain per day. These differences, although small, were consistent.

Animals fed on moist barley each ate $\frac{1}{2}$ lb more meal per day that those fed on dry barley, which consumed $13\frac{1}{2}$ lb per day, on average. This higher intake did not compensate completely for the lower dry matter content of the ration, and on a dry matter basis the intake was $\frac{1}{3}$ lb lower than with the dry barley treatments. There were correspondingly lower liveweight gains per day (an average of 2·34 lb, as compared with 2·47) and the animals took longer to reach slaughter weight. Conversion ratios of dry matter were not so good, probably as a result of these factors.

Health

At slaughter 16 per cent of the animals were found to have liver abscesses. This condition was apparently unrelated to treatment. One animal died suddenly from peritonitis following a burst liver abscess.

Conclusions

There was little, if any, difference in animal performance, whether the barley portion of the ration was rolled or coarse ground. There was, however, a difference in favour of dry rather than moist stored barley. This difference

appeared to be connected with a higher dry matter intake per day. However, it must be remembered that the intake of moist barley was probably depressed as a result of its mouldiness during the later part of the trial, and that this prevented a true assessment of the effect of moisture content from being made. Further work will be carried out to explore this more fully; after this the result will be reported in greater detail.

WINTER HOUSING FOR SHEEP

J. M. Rablah, *Drayton Experimental Husbandry Farm*

Winter housing improves conditions for shepherd and sheep and should thereby cut down losses at lambing. Also by keeping sheep and hayracks off the land in the winter, more grass might be expected the following summer. Trials at Drayton (1961–67), Rosemaund (1962–66) and Great House (1964, 65, 67) indicate that winter housing does not necessarily reduce lamb losses and that there is little extra grass.

The breeds used were Scotch Half-breds (Drayton), Welsh Half-breds (Rosemaund), and Gritstones and Mashams (Great House). About two months after tupping, groups of approximately thirty ewes were selected at random and balanced for age and weight. Some groups were housed and others were left to remain on the grass at known stocking rates, which ranged from two to five ewes per acre.

Effect on Ewe Performance

At Drayton the groups at grass were stocked throughout the year at three and four ewes per acre and hay was fed *ad lib*. Hay intakes averaged 2·25 cwt per ewe compared with 2·8 cwt for winter-housed ewes. This represents a 20 per cent saving of hay. At Rosemaund, at two and four ewes per acre, an 80 per cent saving of hay was achieved by feeding it to the ewes at grass only when necessary. At Great House hay consumption by the out-wintered ewes was negligible in the first year, when the ewes grazed a large acreage, but in the next two years, with five ewes per acre, the hay consumption was the same as with the winter-housed ewes. The effect of resting the land on the re-growth in the next summer will be discussed later.

The winter-housed ewes were moved inside abruptly at two farms and at the third farm they were confined at night only for several days to accustom them to the change in conditions. Both methods gave satisfactory results. In the first year at Rosemaund a low roofed building was used, but it was felt that the ewes were too warm in it, and they did in fact shed some of their wool. It was therefore decided that a well ventilated building without draughts was adequate for sheep. Investigations at Drayton then showed that exercising the ewes or the use of straw or slates for bedding did not affect the performance of the ewes.

Feeding was based on good quality hay given *ad lib*. Restricting the hay required extra rack space and daily rationing, and trials showed that ewes fed in this way gained less weight and produced lighter lambs than ewes fed hay

ad lib. A steaming-up ration was fed in the last 4–6 weeks of pregnancy, increasing from ¼ lb to 1 lb or 1½ lb per day. At Drayton a ration of equal parts of oats, barley and beans was used.

The most consistent effect of winter housing was that lambs born to winter-housed ewes were lighter; with twin lambs this difference was about ¾ lb per lamb. However, the most surprising feature of the results was the higher number of live lambs born to winter-housed ewes compared with ewes remaining outdoors at grass.

Live lambs born per 100 ewes
(Average of all trials at each centre)

	Winter housed	*Wintered at grass*
Drayton	179	170
Great House	151	132
Rosemaud	168	159

The Rosemaund results were influenced by a high proportion of barren ewes in the group wintered at grass in the final year. At Drayton and Great House, a greater number of live lambs from the winter-housed ewes was obtained consistently each season. This is difficult to explain. The ewes were selected at random two months after tupping. No re-absorption of the foetus is known to take place after this time and yet no aborted foetuses were found on the out-wintered plots; nor is the difference accounted for by a higher incidence of still-births in the out-wintered flocks.

At Great House the ewes were turned out before lambing, but at the other farms the winter-housed ewes were lambed inside, moved to individual pens and turned out to grass, usually within twenty-four hours. These methods of management ease the pressure on buildings but perhaps put undue stress on the ewe and her lambs. As a result the lamb losses in the first two weeks after birth were no better, and in one year at Great House much worse, than with the out-wintered groups. In the context of lamb losses, it should be emphasized that the extra facilities and protection from the weather at lambing that winter housing provides, did appear to save the weaker lambs. The survival rate of light lambs is usually less than heavier lambs, but on the two farms that lambed inside, the losses of the generally lighter lambs born to the housed ewes were no greater than those of the heavier ones in the outside group. At Drayton these lamb losses were about 5 per cent for in-wintered and out-wintered groups, but the shepherd had only 30 ewes outside and some 450 ewes inside. Consequently any trouble in the out-wintered group was detected more easily than it would have been in a larger flock.

Once at grass, the performance of the lambs from the winter-housed ewes was similar to those from ewes wintered at grass.

At Great House in two out of three years the out-wintered group produced fleeces which were ½ lb heavier than winter-housed ewes, but in general fleece weights were similar for both groups. The fleece quality in the winter-housed ewes was lower than in the groups which remained at grass, because of a weakness in the staple. This was probably caused by the change in nutrition either at housing or at turn-out. Although the lower quality was clearly seen by the wool graders it resulted in a drop of only a few pence per fleece.

It has been suggested that the productive life of the ewe may be increased by winter housing. The period of the trials was not long enough to study this

aspect and it can only be stated that some ewes at Drayton were in-wintered for six consecutive years and were still in good condition at the end of the trials.

Effect on the Pasture

Taking the ewes off the land three months before lambing might be expected to result in a greater production of grass in the following summer. Trials on leys at Drayton, compared winter stocking rates of three and four ewes to the acre with resting the pasture. In the spring the grass was grazed by ewes and lambs at stocking rates of 3 and 4 ewes per acre, apart from small areas left to grow on for a June hay cut. In four out of five years winter-resting produced no yield increase in the hay crop. However, early in the season there was more grass for the grazing sheep on the rested plots. The average increase in yield in early April was 50 per cent but this had dropped to 24 per cent by late April. This earlier grass resulted in a slightly higher percentage of lambs sold fat before weaning. However, in terms of total gain of lamb per acre or in the overall percentage of lambs sold fat, there was no advantage in resting the grass.

In contrast, at Rosemaund on permanent pasture (4 years) and a ley (3 years) at two and four ewes per acre during the winter grazing period, the rested plots yielded more hay than the grazed plots in all years except the first. The increase over plots grazed throughout the winter at four ewes per acre was 13 per cent on permanent pasture and 15 per cent on leys. This average advantage of nearly 7 cwt of hay per acre would provide enough extra hay (over and above their requirements if the ewes stayed out at grass) to winter-house three ewes. The main difference in management between the two farms was that at Drayton hay was fed *ad lib* whilst at Rosemaund it was fed only when necessary. This might have resulted in a lighter grazing pressure at Drayton, which would have diminished the effect of winter grazing and treading.

The highest winter stocking rate in these trials on pasture re-growth was four ewes per acre. If stocking rates were increased then the effect of winter grazing would be expected to be greater.

RECENT WORK WITH HILL SHEEP

R. I. W. A. Richards, *Pwllpeiran Experimental Husbandry Farm*

Indoor and Away Wintered Ewe Lambs

During the winters of 1964/65 and 1965/66 at Pwllpeiran, three types of floor for indoor wintering of ewe lambs have been investigated and the lambs' performance compared with that of away-wintered ewe lambs, i.e., 'tack'. The type of floors compared were:

(1) Slats — 1¼-in. slats with ¼-in. bevels (⅝ in. between slats)
(2) Perimeter — As in (1) but with a 1 ft. 9 in. solid perimeter of hardboard.
(3) Solid — Deep litter of wood shavings.

TABLE 1

Performance per ewe lamb

	Oct.—April liveweight gain	June weight (at shearing)	Wool weight	Food cost
Slats	3·8	50·5	3·43	32s. 1½d.
Perimeter	4·0	49·3	3·20	31s. 10½d.
Solid	2·6	49·2	3·23	31s. 4¼d.
Tack	9·1	56·8	4·14	35s. 0 d.

Over the two years, the lowest liveweight gain between October and April was by the ewe lambs on the solid floor, while those on slats and the perimeter type of floor gave comparable liveweight gains. On the other hand, ewe lambs wintered away (tack) gave an appreciably better increase in liveweight than any of the groups in-wintered at home and resulted in a heavier and bigger-framed animal at two years of age, i.e., at the first lambing. Furthermore, the away-wintered lambs gave appreciably more wool (12 per cent) over the first two years.

The feeding cost of the in-wintered animals is comparatively cheaper than the price paid for tack, but when the labour and building depreciation is added to the cost of home-wintering, the total cost is greater than the price of tack plus transport charges.

Following on the performance of these animals as two-tooth ewes, those away-wintered as ewe lambs gave a slightly better lambing percentage (2–3 per cent) than those wintered at home as ewe lambs. Furthermore, records of sale show that the bigger-framed ewe resulting from good away-wintering on average commands a higher price when drafted at 4½ years old.

PROTEIN TO IN-LAMB EWES

Results of experiments on the supplementary feeding of two year old Welsh mountain ewes have shown that the optimum level of crude protein in the supplement is around 12 per cent. This type of ration consists of 92½ per cent cereals and 7½ per cent vegetable protein (Soya bean meal).

In four years' trials (1964–67) two year old ewes which had performed similarly as yearlings were given 6 oz per head per day of concentrates containing 10, 12, 15 and 18 per cent crude protein during the last six or eight weeks of pregnancy. In addition, there was a control group of ewes receiving no supplement to the grazing on semi-improved hill pasture which was common to all five groups.

The results have been very consistent in that the 12 per cent group has been superior to all the other in terms of lambing percentage and has given comparable lamb weaning weights. There were only marginal differences in in lamb birth weight and wool weights between treatments. However, the performances of the 12 and 15 per cent groups, measured as total liveweight of lamb produced at weaning, were superior to those of the other treatments. When the cost of supplementary feeding is considered in relation to increased liveweight produced by the supplemented groups over the control, the following results are obtained:

TABLE 2

Comparative cost of lamb liveweight gain over control per 100 ewes

	10%	12%	15%	18%
Increased liveweight of lamb over control in lb	343	409	410	153
Total cost of food in shillings	450	466	500	529
Cost per lb of extra liveweight produced	1s. 3½d.	1s. 1d.	1s. 2½d.	3s. 5½d.

At the present market value of store lambs, the groups giving a possible economic return over food cost are 10, 12 and 15 per cent crude protein, and when prices are below 1s. 2d. per pound liveweight, only the 12 per cent level will be economic. These results refer to the performance of two year old ewes, which are admittedly the least productive section of the flock, and older ewes would be expected to produce more lambs with better liveweights at weaning; nevertheless, it illustrates the importance of keeping the cost of supplementary feeding within economic limits.

On appraisal of the first three years' results of the supplementary feeding trial with two year old ewes, it would appear that the percentage of lambs born dead and the incidence of late abortions vary according to the protein level in the supplementary feed. The results to date show that the lowest percentage is in the 12 per cent group, whilst the highest percentages are in the control (no feed) and the 18 per cent groups. In order to give fuller information on these aspects, the feeding trial will continue for another year. In addition, a further trial on supplementary feeding of three, four and five year old ewes was initiated in 1967 to compare different levels and sources of protein, i.e., non-protein nitrogen versus vegetable protein. It is hoped that this will give further information on the distribution of lambs born dead and late abortions in the various treatments.

SHORN AND UNSHORN LAMBS

It is customary, in the mid-Wales area, to trim or shear both the ewe and wether lambs in late June or early July, in the belief that they will thrive better. Indeed, in the case of the wether lamb, it is almost essential to do it because a trimmed store lamb will always command a higher price per pound liveweight in the local markets. The three years' results show that there is very little difference between the performance of shorn and unshorn lambs, except that the shorn lamb is fit for slaughter about seven days earlier. If the cost and labour difficulties involved in shearing the lambs are taken into account, the financial gain can only be marginal when the hill farmer is in a position to fatten his own lambs.

TIME OF WEANING

Over the last three years, three groups of both ewe and wether lambs have been weaned in mid-July, mid-August and mid-September, i.e., at approximately twelve, sixteen and twenty weeks old. The mid-August group has given better results than either the early or late weaned groups. The ewe

lambs weaned at sixteen weeks had a higher liveweight gain up to October and the wether lambs in the group were also heavier at slaughter, but there were only slight differences in the number of days taken from weaning to slaughter and killing out percentages.

At Pwllpeiran, the lambs are not weaned on to absolutely clean land, i.e., land that has not been grazed by sheep in the previous twelve months. It is considered that very few, if any, mountain sheep farms could practice this system with the very limited acreage of enclosed field available; and as these results indicate that there is very little gain by early weaning, the lower land would be used to greater advantage by a more productive type of stock.

USE OF GIBBERELLIC ACID ON RHUBARB FOR FORCING

M. W. Case, *Stockbridge House Experimental Horticulture Station*

The first trials in this country on the use of gibberellic acid on rhubarb for forcing were carried out at Stockbridge House E.H.S. in Yorkshire in the winter of 1965–66.

In normal practice dormancy breaking of rhubarb, which must precede forcing, is achieved by exposure of the plants to those low temperatures which occur naturally during the autumn and early winter.

Two possible advantages from the use of gibberellic acid were envisaged—the dormancy of roots might be broken and yield might be increased. Such chemical breaking of dormancy would make earlier forcing possible, because it would be independent of naturally occurring low temperatures. This in turn would make the double cropping of rhubarb sheds in any particular forcing season economically more reliable. In the short term, earlier forcing could reasonably be expected to be rewarded by higher prices at the beginning of the season.

For the realization of these advantages it is required that gibberellic acid should be realistically priced, and that its use should not lead to an unacceptable loss of quality in the forced crop, or to the presence of dangerous residues. Experiments have shown interest in the chemical to be fully justified.

During the forcing season of 1965–66, two year old roots of the early variety Gilling's Early were lifted when nearly fully dormant (24 cold units)*, when semi-dormant (99 cold units) and after dormancy had been fully broken (221 cold units), and housed in plots of 8 roots. Two year old roots of the late variety Victoria were lifted after receiving 24 cold units and when dormancy was fully broken (more than 525 cold units). On each occasion, gibberellic acid was applied to the roots before soiling over and watering since the material was known to hydrolyse in contact with wet soil. Two rates of application and a control were included. There were signs of bud burst on treated plants of 'Gilling's Early' within four days of application of gibberellic acid. Yields obtained are given in the table.

*1 cold unit equals 1°F below a base of 49°F, recorded at 9.00 a.m. G.M.T. on a 4-in. soil thermometer, daily readings being added to a cumulative total started afresh each September.

Gibberellic acid per plant	Marketable yield (lb per root)			
	Gilling's Early			Victoria
	24 c.u.	99 c.u.	221 c.u.	525 c.u.
0 mg	3·5	3·7	5·0	3·4
25 mg	4·7	7·1	5·7*	4·2
100 mg	6·3	6·6	7·0	6·1

* 50 mg in 1 litre c.u.—cold units

No worthwhile crop was obtained from the dormant 'Victoria' plants in spite of treatment.

In that the treatment of substantially dormant 'Gilling's Early' roots led to a marked increase in marketable yield, some degree of dormancy breaking is thought to have occurred, but this was insufficient to cause active growth of non-chilled 'Victoria' plants. However, in both varieties, plants with dormancy fully broken were induced to give bigger yields by treatment with gibberellic acid. This was largely due to an increase in the number of sticks per plant. The quality of the sticks produced was at least as good from the treated as from the untreated plots. The extent to which the crop may be advanced by early forcing and the use of gibberellic acid, as opposed to forcing in the normal season without the use of chemicals, will vary according to the rate of accumulation of cold units in any particular year. In the experiment for which results are given in the table, the greatest differences were of the order of three weeks.

The problems of time and method of application of the gibberellic acid were investigated in 1966–67, since pouring solutions of the material over dormant roots as in the 1965–66 experiment seemed wasteful of an expensive chemical.

A comparison was made between the yield of Gilling's Early roots receiving 25 and 100 mg of gibberellic acid in $\frac{1}{2}$ litre of water as a drench before soiling over and watering (the method used hitherto) and roots receiving from 25 mg to 200 mg as mist sprays (25 ml of fluid per plant) after soiling over and watering and allowing time for drainage. Mist sprays, it was thought, might be absorbed into the water film covering the buds and thus the gibberellic acid would be held by the plant, instead of some of it running off onto the floor as in the drenching method of application. However, drenches were found to be more effective than mist sprays, 25 mg of gibberellic acid applied as a drench resulting in nearly as big a yield as 200 mg applied as spray.

In a further trial 50 mg per plant of gibberellic acid were given at different times after housing the plants, or applications were split and given over as many as five weeks. Delayed or split applications resulted in the plants having some foliage at the time when the spray was given; this it was hoped would provide a better absorbing surface than had been available in previous trials. It was found, however, that delay in application resulted in reduced yields where only one application was made. Split applications resulted in yields of only the same order as could be achieved with a single application made as soon as possible after housing. Studies are in progress on the

influence of forcing temperature on the response to gibberellic acid, and to determine the optimum volume and concentration of gibberellic acid solution to use on early lifted 'Timperley Early' rhubarb.

In the 1967–68 season attempts to obtain uptake of gibberellic acid in the field in August (full leaf cover) or September (partial leaf cover) were successful, as shown by the fact that green leaf remained on the treated plants later than usual in the autumn. However, when the foliage was removed and the plants were taken to the forcing shed at 27 cold units, little if any benefit from the gibberellic acid remained. The same quantity of gibberellic acid—25 or 100 mg per plant—applied in the forcing shed to roots not previously treated in the field, gave the customary yield increases.

It is at present suggested that gibberellic acid is applied in the forcing shed within a week of housing. Cost of materials is relatively high and will probably be between 4d and 1s. 9d per root depending on the rate of application. With the biological knowledge so far obtained, and a knowledge of market returns, the producer of this crop will be able to determine the most appropriate rate of application.

Gibberellic acid occurs naturally in plants, and after examination of relevant residue data its use has been officially approved on rhubarb for forcing.

CUCUMBER—AUTUMN PRODUCTION

R. L. Tite, *Lee Valley Experimental Horticulture Station*

Commercially the bulk of the English cucumber crop has finished by the beginning of October from main crops planted in February, and by the end of October from second crops planted by mid-July. The object of the investigation at the Lee Valley Experimental Horticulture Station is to find out how late into autumn it is economically worth while to produce cucumbers in order to extend the season for English cucumbers and to compete with imported produce.

In 1967 the autumn crop followed the early-main crop tomatoes enriched with CO_2, in eight east-west growing compartments. Preparation of the houses for the cucumbers was kept to a minimum and, after removing the tomato plants, the borders were lightly forked and beds consisting of lines of straw wads 8in. deep with a layer of peat on top were constructed on the border soil, except in two compartments where the beds were placed on the residue after growing the tomato crop on double lines of straw wads isolated by polythene from the border soil. The varieties chosen were Butcher's Disease Resister, Sporu and Bestseller (the latter being the best maincrop variety at the Station in 1966 and 1967).

Seed was sown on two dates, 5 and 17 July and the crop planted on 1 and 14 August respectively. 'Hard' plants with a high dry matter content were propagated in order to improve resistance to stem diseases in the poorer light intensities of October and November. The plants were grown as vertical cordons at a density of 4800 plants per acre. In addition to a traditional Dutch trimming system for cordons, there was a small comparison of a

'no trimming' treatment; these plants were not trimmed after the initial framework was completed.

Apart from the initial release of CO_2 from the decomposing shallow layer of straw which reached a peak of 500–600 v.p.m. in three weeks and finished six weeks after planting, four compartments received supplementary enrichment with pure CO_2 to 1000 v.p.m. from $\frac{1}{2}$ hour after sunrise to $1\frac{1}{2}$ hours before sunset. This commenced on 27 September when ventilation ceased apart from a minimum of night air to reduce the likelihood of infection with *Botrytis* and *Mycosphaerella*.

Results

Harvesting commenced on 29 August from the 5 July sowing and on 7 September from 17 July sowing, and yields are given in the table. Picking ceased on 4 December when it was considered uneconomic to continue the crop as the input of heat, labour, etc., would soon be greater than the output. The yields obtained are encouraging as 3 tons per $\frac{1}{10}$ acre ($\frac{1}{2}$ flat per ft run of bed) is considered to be a reasonable commercial yield from a mid-July planting.

Cucumber: final yields (tons per tenth acre)

Variety	No additional CO_2		CO_2 enriched	Mean
	Beds not isolated	Beds isolated	Beds not isolated	
Sowing date: 5 July				
Sporu	3·84	4·51	5·15	4·50
B.D.R.	3·02	3·59	4·32	3·64
Bestseller	4·11	4·77	5·00	4·63
Bestseller trimming (a)	4·35	4·26	5·29	4·63
Bestseller trimming (b)	3·65	4·15	4·85	4·22
Mean	3·79	4·26	4·92	
Sowing date: 17 July				
Sporu	2·58	2·59	3·37	2·85
B.D.R.	2·21	2·27	2·91	2·46
Bestseller	2·65	2·64	3·52	2·94
Bestseller trimming (a)	2·64	2·81	3·46	2·97
Bestseller trimming (b)	2·62	2·68	3·32	2·87
Mean	2·54	2·60	3·31	

(a) Dutch trimming
(b) Dutch framework then no trimming

Bestseller and Sporu, which were the best maincrop varieties in 1967, proved to be better than Butcher's Disease Resister. Plants receiving supplementary CO_2 after the end of September very quickly gave increased yields, and this treatment produced the highest total weight for each sowing date. The additional CO_2 gave more prolific and vigorous growth which resulted in a greater number of cucumbers. As with CO_2 enriched tomatoes, these

plants were 'softer' but a few losses occurred due to stem rots. The plants on isolated beds gave an equal yield to those on border soil, but the work involved in the preparation of the house was considerably less. The 'no trimming' treatment was not as satisfactory as the traditional method and the plants did not carry the extra numbers of cucumbers which it was understood the treatment would produce.

Although this work has been conducted for only one season, the results indicate that economic crops of cucumbers at current prices can be produced until the end of November from later than normal sowings in the Lea Valley and other areas in the south of England where modern glasshouses, orientated east-west, are used for growing the crop.

CONTROL OF CO_2 ENRICHMENT OF GLASSHOUSE ATMOSPHERES BY MEANS OF A SOLARSTAT

D. A. G. Jones, *Fairfield Experimental Horticulture Station*

The practice of CO_2 enrichment of glasshouse atmospheres is now firmly established but there is a need for its most economical use, especially in lettuce growing. One approach to this problem has been investigated at Fairfield. Based on the proposition that the utilization of CO_2 by the plant is more efficient as the level of solar radiation increases, several experiments have been carried out to compare continuous CO_2 enrichment against CO_2 enrichment in bright sunlight only. A simple instrument has been developed to carry out the latter operation and is described below.

This instrument consists of a rod thermostat, the bar of which is matt black in colour and covered with a sleeve of translucent P.V.C., connected to a solenoid valve inserted into the pipe carrying the gas. The bar of the thermostat is put in an upright position above the crop and set to 10°F (5·6°C approx.) above the day temperature being maintained by pipe heat. When the sun appears from behind clouds the direct solar radiation heats the black bar and this rise in temperature can be as much as 50°F (28°C), depending on the intensity. This activates the bimetal spiral of the thermostat and the central contact moves to the 'hot' position, the solenoid valve then opens and allows the gas to flow into the glasshouse. In periods of dull weather the contact is in the 'cold' position and the solenoid is closed. In the early morning, when there is a change from a cool night to a warm day with bright sunlight, there may be a time lag of about $\frac{1}{2}$ hour before the circuit operates. This, however, fits in with the general timing of CO_2 applications which are not normally commenced until $\frac{1}{2}$ hour after sunrise. Later in the day, when the thermostat has assumed the day ambient temperature, there is a delay of about 5 minutes before the system operates; a similar delay takes place when conditions change from sun to cloud. This delay is an advantage as it ensures that, in rapidly changing radiation levels, the glasshouse is kept reasonably charged with CO_2. The assembly at Fairfield is set to switch on when a Campbell-Stokes sunshine recorder card, sited in the

open, begins to burn, i.e., 1,000 foot candles (fuller details of the circuit and its component parts can be obtained from Fairfield E.H.S.)

A trial on tomatoes has shown that CO_2 enrichment in bright sunlight only gave virtually the same yield as continuous enrichment, with a 40 per cent saving in the amount of CO_2 used. A similar experiment with lettuce has been carried out, and continuous enrichment gave a 14 per cent increase in weight over enrichment in bright sunlight only, although this increase was not significant. There was however, a 30 per cent saving in the quantity of CO_2 used in the latter treatment which gave a 33 per cent increase in weight compared with a non-enriched crop. A considerable reduction in the cost of CO_2 enrichment was therefore achieved with almost the same crop response. Further work is, however, required before firm commercial recommendations can be given.

DAHLIAS—PRODUCTION OF HEALTHY TUBERS UNDER GLASS

F. G. Lloyd, *Lee Valley Experimental Horticulture Station*

For several years growers have been increasingly concerned with the serious losses caused by virus infection of dahlias grown in the open. Dr. R. Cammack of the Plant Pathology Laboratory at Harpenden carried out a detailed survey on many nurseries in England, and the level of virus infection present convinced him that it would be impossible to maintain healthy stocks in the open, mainly because of the lack of isolation from other plants, and the difficulty of ensuring freedom from aphids, which act as vectors of the virus.

In collaboration with Dr. Cammack an experiment began in 1966 to investigate the possibility of growing and maintaining healthy stocks of dahlias in an insect-proof glasshouse. Pot tubers appeared to be a satisfactory method of growing and overwintering stock and, in the first year of the experiment, all plants were grown in $3\frac{1}{2}$ or $4\frac{1}{4}$-inch plastic pots. To satisfy the plant health requirements of any potential importing country, a loamless compost consisting of peat and perlite was used.

Summary of Results in 1966 and 1967

1966

In 1966 only one variety, Newchurch, made satisfactory tubers by mid-October when grown in natural daylength from three propagation dates, with cuttings taken in early April, early May and early June. There was little difference between the two sizes of pots and no difference in tuber formation from three levels of nutrition.

However, three varieties, Doris Day, Polly Peachum and Tinker's White, were given short day (10 hours) treatment commencing either in mid-June or mid-July and by mid-October plants receiving short days from mid-June had generally produced satisfactory tubers; the plants which had received short day treatment one month later produced rather smaller tubers. Only a few very small tubers were formed on the control plants which were grown in natural daylength.

1967

In 1967 the most promising treatments from 1966 were examined in more detail in addition to the following new treatments:

Beds of peat/perlite compost over polythene—plants grown at the same density as in pots.

Two types of compost—J.I.P.2 and peat/perlite.

Two types of pot—3½-in. clay and 3½-in. plastic.

As in 1966 plants grown in natural daylength produced very poor tubers or no tubers by mid-October. Plants grown with short day treatment either from mid-June or mid-July produced more satisfactory results. Plants grown on beds produced large, rather long tubers which would be difficult to pack, transport and store, and in addition would require more space in the propagation house. The plants grown in J.I.P.2 compost produced very satisfactory tubers and those in clay pots were rather better than in plastic. The least satisfactory results were obtained from plastic pots with peat/perlite compost.

Future Studies

Several aspects of pot tuber production still need to be clarified, such as the optimum compost and feeding required to produce firm round tubers, and these will be examined further in 1968. An earlier propagation date will also be included. Cuttings will be taken in late January before commercial growers reach the peak period of propagation for their normal dahlia plant trade.

All plants will be given short day treatment (10 hours) from 1 July to 1 October, by which time daylength will be 12 hours or less.

EFFECT OF CONTINUOUS LIGHTING ON FLOWER PRODUCTION OF CARNATIONS

R. F. Jackson, *Fairfield Experimental Horticulture Station*

A two-year carnation crop planted on 16 June 1966, was primarily an experiment to test the yield and quality of 18 virus-free clones released by the Glasshouse Crops Research Institute.

In addition an observation was carried out on the effects of a period of continuous lighting during mid-winter in the hope of bringing forward flowering to a time when prices were higher than with the normal summer flush of bloom. This follows the work of G.P. Harris of Reading University on the effect of daylength on the flowering of carnations.

For the observation, four beds each 4ft × 70 ft were used, the two outer beds acting as controls. Of the two beds given the lighting treatment the first had 150-watt bulbs, spaced at 6ft intervals, 2 ft 6 in above the plants, and the second 100-watt bulbs, spaced at 6 ft intervals, 3 ft above the plants.

The varieties included were: Cocomo Sim, Dusty Sim, Tangerine Sim, White Sim, William Sim and Ashington Pink, of which there were four

clones of the first three and two clones of the last three varieties. The planting distance was 6 in. × 6 in.

Lighting started on 17 January and continued for 42 consecutive nights, switching on half an hour before dusk and cutting off half to one hour after dawn. The beds treated were each surrounded by black polythene to prevent any of the light reaching the control beds.

At the start of the treatment the growth was mostly vegetative as the first flush of blooms had been harvested and very few buds were developing. The shoots were not all of the same length and so the distance of the lights above the plants had to be an average. At the end of the period of treatment the growth on these beds appeared to be a lighter green and more fleshy than on the control beds, also the stem and internode length appeared to have increased.

In mid-April a considerable number of buds had developed on the treated beds and vegetative growth seemed to be more vigorous than on the control plots. Buds on the controls were still very small compared with those on the treated beds. A considerable flush of bloom appeared on the treated beds beginning in early May as can be seen from the monthly totals in the table. The quality was good and roughly two months ahead of the main flush of bloom of the control beds.

	Blooms per sq. ft.					
	150-watt bulbs 2ft. 6in. above the crop		100-watt bulbs 3ft. above the crop		Control	
	Monthly total	Accumulated total	Monthly total	Accumulated total	Monthly total	Accumulated total
Oct	4·34	4·34	5·28	5·28	2·71	2·71
Nov	6·33	10·67	7·01	12·29	5·96	8·67
Dec	4·14	14·81	3·07	15·36	4·01	12·68
Jan	2·02	16·83	1·73	17·09	2·67	15·35
Feb	1·10	17·93	0·75	17·84	1·16	16·51
Mar	1·51	19·44	0·98	18·82	1·41	17·92
Apr	1·15	20·59	0·98	19·80	1·31	19·23
May	9·34	29·93	10·36	30·16	2·92	22·15
Jun	4·75	34·68	5·15	35·31	6·75	28·90
Jul	4·60	39·28	4·07	39·38	8·13	37·03
Aug	9·61	48·89	8·89	48·27	7·54	44·57

The flowering induced by the lighting treatment ended in early June and was followed by slight depression, but flowering returned to normal in August. The bed which received the higher intensity of illumination was slightly in advance of the other but it seems doubtful if this would justify the cost of the extra current used. The plants in the treated beds were some 12 in. shorter than the controls; this is an extra advantage in the management of the crop.

Conclusion

This observation on the effects of the lighting of carnations confirms the possibilities of controlled flowering of the crop. Considerable practical information is now available on the subject, mainly due to the work of

Mr. R. J. Cox, at Sussex Nurseries Ltd., and the benefits of controlled flowering, both in higher returns and easier crop management, cannot be ignored by the commercial grower.

STORAGE OF NARCISSUS BULBS

Elizabeth D. Turquand, *Kirton E.H.S.*
A. R. Rees, *Glasshouse Crops Research Institute*

In experiments carried out at Kirton E.H.S. on the storage of Narcissus bulbs, a range of storage temperatures has been tried after lifting for forcing, and to reduce damage caused by hot water treatment (H.W.T.).

Storage For Early Forcing

Temperature and duration

As a result of Dutch work, it has been known for some years that storage at 93°F (33·9°C) for 3 to 5 days, or 86°F (30°C) for 2 weeks, immediately after lifting, forwarded the flowering of a number of Narcissus varieties during forcing. A series of experiments has been carried out to find out how critical is the temperature and duration of warm storage.

In one experiment, no difference was noted in flower quality or flowering date when 'Golden Harvest' was stored at 93°F for 3, 4, 5 or 6 days, but warm storage for five and six days gave earlier flowering with 'Carlton'.

In subsequent trials 'Golden Harvest' and 'Fortune' were stored at 86°F, 90°F (32·2°C) and 95°F (35°C) for 2, 5 and 8 days in an attempt to find the maximum and minimum temperatures and periods consistent with earliness and flower quality. All warm-stored bulbs flowered earlier than controls not given warm storage, the earliness increasing with temperature and duration up to 10–12 days for bulbs stored at 95°F for 8 days. The duration, but not the temperature, had a small effect on the percentage of grade 1 flowers, 8 days reducing the number of grade 1 flowers by 14 per cent compared with 2 days. Storage at 95°F for 5 days gave the earliest flowers consistent with satisfactory quality and, as a result, all bulbs of 'Fortune' and 'Golden Harvest' required for forcing before Christmas at Kirton E.H.S. are now given this treatment with excellent results. 'Carlton' and 'Unsurpassable' have also responded to this treatment and have been forced by Christmas.

Date of lifting and storage

In one experiment, storage at 93°F for 3 days was compared with storage at 86°F for 14 days immediately after lifting on 20 and 27 June, and 4 July. Lifting on 20 June followed by storage at 86°F for 14 days gave the earliest flowers, but flower diameter was reduced when compared with later liftings. Golden Harvest produced more first grade flowers after storage at 93°F for 3 days than after storage at 86°F for 14 days.

An experiment was started in 1966 to assess the importance of a delay between lifting and the start of warm storage with 'Golden Harvest' and 'Fortune'. Bulbs were lifted on 28 June, 5 and 12 July and stored at 95°F for 5

days, starting 3 days and 9 days after lifting. In 1966 a nine day delay before warm storage, even after the last lifting on 12 July, had no important effect on flowering date or quality, but this experiment is being repeated since different soil and weather conditions may produce different results.

Storage after warm storage

Bulbs stored at 63°F after warm storage reach the stage of flower development ready for cool store (formation of trumpet) rather earlier than bulbs stored at a higher temperature. High-temperature treatment at lifting has very little effect on the date at which bulbs are ready for cool store compared with bulbs not given the treatment.

Prevention of Flower Damage By Pre-H.W.T. Warm Storage

Storage at high temperature immediately before H.W.T. is very effective in preventing the damage caused by early H.W.T. In one experiment 99 per cent of 'Fortune' flowers and 97 per cent of 'Golden Harvest' flowers were damaged by H.W.T. in July after storage at ambient temperature, while only 9 per cent and 12 per cent respectively were damaged by the H.W.T. after storage for 7 days at 86°F. In a later experiment, 86°F for 7 days was slightly more effective than 93°F for 3 days in preventing flower damage in 'Golden Harvest' and 'Fortune'. Storage at 70°F (21·1°C) and above conditions eelworm to resist H.W.T. however, and must be used with care.

Warm storage after H.W.T. had an adverse effect on growth if the bulbs were not also warm stored before H.W.T. A week at 86°F after H.W.T., when the bulbs had been stored at ambient temperatures before H.W.T., reduced bulb yields of 'Carlton' and 'Actaea', killed the flowers and caused leaf distortion. A serious reduction in flower number was observed when these bulbs were forced the next year.

Another aspect of storage before H.W.T., which is being explored, is the effect of low temperatures before H.W.T. Severe leaf damage had been observed for several years at Kirton E.H.S. after H.W.T. during cool summers and to investigate a possible cause, bulbs of 5 varieties were stored for 3 weeks at 45, 50, 55, 60 or 65°F (7·2, 10, 12·8, 15·6 or 18·3°C) before H.W.T. on 23 August 1965 for 3 hours at 112°F(44·4°C). Bulb yield increased and leaf and flower damage decreased with each 5°F rise in storage temperature. 60°F seemed to be the critical temperature for leaf damage, although 'Carlton' showed some leaf damage even at this temperature. 'Actaea' and 'Cheerfulness' were both blind after storage at 55°F before H.W.T. and storage at 65°F was necessary to produce a good flower crop. This work is being continued further, because recent cold summers have stressed the importance of storage conditions before H.W.T. It is hoped to find a compromise period and temperature, economically possible for growers with large acreages of bulbs, and at a temperature low enough to allow an efficient kill of the eelworm.

DRY PACKING AND OTHER FACTORS AFFECTING FLOWER LIFE OF NARCISSUS

L. W. Wallis, *Rosewarne Experimental Horticulture Station*

Imported dry packed flowers have, over the past few years, enjoyed a good reputation and have made good prices. This may well be because, in these cases, good quality and method of packing have been associated in the mind of the buyer. Home produced flower packs tend to be more variable in both condition and contents and, for this reason, they have sometimes had a less good reputation and prices have been lower, whether the flowers have been packed dry or watered in the traditional way before packing. Ideally growers in this country should use a more consistent method of packing tied to a set standard of quality grading.

Good dry packs can be supplied if required and the market is rapidly coming to accept dry packs for bulb flowers.

A number of factors, economic, labour, etc., have led to changes in flower marketing over the last few years. At Rosewarne we have been concerned with these changes and some of the subjects studied are described below.

Review of Narcissus Flower Experiments

Stage of picking

Apart from double varieties and a few others, all narcissi open from buds picked at an early stage of development. The more fully developed they are at picking the better the flower, but for marketing, when two days or so for transport and distribution has to be allowed, the best value is given by buds picked at the goose-neck stage (Plate VII). These open up about the time they are sold and give good flowers with a full vase life.

Opening before or after transport

The vase life of flowers opened before or after transport to the market has been compared. Since they open up equally well after the journey and last as well this is the best sequence to adopt; the flowers would be one or two days older before despatch if opened before transport to market.

Conditions during opening of flowers

Most varieties open up best at moderate temperatures (45°–60°F) and lighting at this time may improve their colouring. Narcissus 'Soleil d'Or' is an exception. It opens better at lower temperatures and its colour is enhanced by exposure to low temperature, i.e., 35°F (1·7°C). Colour is influenced too by the environment of the growing crop, i.e., temperature and light intensity. This is probably the reason for the exceptional depth of colour of some varieties when grown on the Isles of Scilly.

Containers for flowers in water

In commercial practice buds or flowers are kept in water in a variety of buckets, tins, tanks and earthenware containers. Our investigations show that the type of water container has no effect at all on the vase life of the flowers.

Additives to water

Chemical additives increase the life of some flowers. When comparing water containers for flowers we included treatments with silver nitrate (a bactericide used to inhibit bacterial development in the stems, preventing blockage of the tissues). This has no effect. In fact flowers with substantial lengths of rotted stems may last as long as those free of rot. We found that the best way to keep the flower water clean and free from offensive bacteria was to change it frequently.

Storage

It is not yet possible to store narcissus flowers for a long time without seriously decreasing their vase life. However, we can keep most varieties for about two weeks at 33°–35°F without losing more than 25 per cent of their potential life. They can be stored either wet or dry. Dry storage is the more practicable but dry stored flowers need partial wrapping in polythene or similar material to prevent excessive drying out.

Dry packing

Dry packing of buds as picked has been compared with buds watered overnight before packing, the buds being left in the bunches for various periods. The dry packed flowers are lighter in colour and they open up into slightly smaller flowers. They have a slightly shorter life but on the other hand, as they are not watered, they are sent to market earlier and in fact have a longer effective vase life than the watered flowers.

Advantages of dry packing

Dry flowers are more flaccid than watered flowers and they pack better with less damage to their tissues. Packed as buds, bunches can be put one on top of the other in layers, thus filling the packs and utilizing the space to the best advantage. They can be packed soon after picking and so arrive at market in a younger condition.

Developments in Narcissus Marketing

Methods have changed over the last century; in some respects they have run one or more full circles in that time. The recent rapid evolution of new techniques is illustrated by comparisons made over an eight year period (1960–8).

Method of packing, 1960

In the system of packing practised at this time flowers were picked in bud but were then fully opened before packing.

Flowers arranged in carefully formed but bulky bunches were packed in two or three rows of bunches in one layer in a box. Of the whole box, one-third was flowers and two-thirds empty space.

The boxes were usually lined with tissue paper.

The expectation of life for the flowers was about four days provided the retailer did not keep them too long before selling them.

Method of packing in 1968

This is in striking contrast to that of 1960.

Flowers are picked in bud, the buds often being bunched at the same time.

Buds are packed as soon as possible thereafter.

Flower boxes are filled as full as possible. By completely filling the boxes it is possible to depend on tightness of package to hold the bunches in place, then no dowels are required for securing the bunches.

Dry packs hold three times as many flowers as did packs of open flowers.

White lined cardboard boxes are used, which eliminate the need for papering.

The new techniques have saved many operations in the packing shed, space and materials. The flowers arrive at market in younger condition and give better value to the purchaser.

CHEMICAL PREVENTION OF SUPERFICIAL SCALD OF APPLES

J. Ingram, *Luddington Experimental Horticulture Station*

Adequate ventilation in bulk bins has been shown to be essential for the satisfactory storage of scald susceptible varieties. Trials at Luddington with the variety 'Bramley's Seedling' have indicated that bins should have at least 8 per cent of the bottom area ventilated and that this amount can still be increased with advantage. Superficial scald occurs mainly on green culinary varieties but 'Egremont Russet' and 'Mutsu' are also susceptible to this disorder.

The standard commercial bulk bin is provided with 4 per cent bottom ventilation located along the junction between bottom and sides where the gaps will not cause any damage to the fruit. This degree of ventilation is adequate for 'Cox' and all other varieties which are not subject to storage scald.

The provision of increased ventilation creates the need for an alternative bin, increases the cost of the bin, weakens construction and also increases the incidence of fruit damage. This increased damage is caused by pressure marks in the form of 'tram lines' occurring on fruit resting over the gaps in the slatted bottom of the bins.

In the trial which continued at Luddington in the 1966–67 storage season, chemical treatment of the fruit with ethoxyquin was introduced as an additional treatment to see whether fruit could be stored satisfactorily in the standard bin with 4 per cent ventilation. 'Bramley' fruit was stored over the period 18 October 1966 to 9 May 1967 under ventilated controlled atmosphere conditions of 8–10 per cent CO_2 and temperature of 38–39°F (3·3–3·9°C).

The fruit was assessed for scald on 22 May and, as in the two previous years, the least amount of scald, where chemical treatment was not used, was found in the fruit stored in bushel boxes where 8 per cent of the fruit was affected. In the bulk bins the incidence of scald increased with decreasing

ventilation ranging from 18 per cent affected in the bins with 16 per cent ventilation to 78 per cent affected in the bins which were lined and loosely covered with polythene sheet. Where the fruit was dipped for 15 seconds in a solution of ethoxyquin (2 pints of Stopscald to 100 gal of water) and stored in standard bins with 4 per cent ventilation, no scald was recorded in May and the treatment did not influence moisture loss or the incidence of fruit rot. When fruit treated in the same way with ethoxyquin was stored in polythene lined and covered bins (creating the most likely conditions for scald to occur) 55 per cent of the fruit was affected by scald.

The results, which are subject to confirmation by further trial, indicate that ethoxyquin can be used successfully to inhibit the occurrence of superficial scald in standard bulk bins. Ethoxyquin was first cleared for commercial use in this country for the 1967–68 storage season. The present cost of the material is £1 16s. 0d. for the 2 pints required per 100 gal of water.

The fruit must be treated as soon as possible after harvesting and the period of dipping should not be unduly prolonged beyond the recommended 15 seconds dip, in order to ensure that the residues, after storage, do not exceed the permitted maximum of 3 p.p.m. At present a 15 second dip is recommended but further information is required on this aspect and on the concentration of the diluted material, as water temperature influences the rate of uptake, the uptake increasing with higher temperatures, and varieties also differ in their rate of uptake. American literature cites the alternative application of ethoxyquin as a pre-harvest spray applied at high volume rate but this is not recommended, as it is difficult to achieve an adequate chemical cover to the fruit. This problem of adequate pre-harvest cover, however, warrants further investigation.

In trials elsewhere chemical treatment of the fruit with diphenylamine has been shown to be a more effective material than ethoxyquin for inhibiting superficial scald but diphenylamine has not yet been cleared for use in this country, and there is also some risk of fruit damage occurring with this material.

SELF-BLANCHING CELERY AS AN UNHEATED GLASSHOUSE CROP

Enid A. Turner, *Luddington Experimental Horticulture Station*

During recent years the demand for celery by the markets has increased, and this crop is wanted not only during the traditional winter months but also during most of the rest of the year. Imports from America have helped to satisfy this demand in the late winter and spring months but for the summer, ways of producing the crop at home are being investigated.

Varieties and strains of self-blanching celery have been grown for some time as field crops to precede the traditional varieties that require blanching. Much more recently, self-blanching celery has been used either as a partially protected crop in frames or as a fully protected crop in unheated glasshouses generally of the Dutch light type. Work on variety testing at the Experimental Horticulture Stations has shown that the variety Lathom Self Blanching is

very suitable for this purpose and that the product is of good quality, being crisp and of good flavour.

This variety was used at Luddington Experimental Horticulture Station in 1967 to grow a fully protected crop in an unheated Dutch light structure. Seed was sown on 13 February and germinated at a temperature of 60°F (15·6°C). Pricking out into seed trays at fifty four per tray took place on 2 March, after which the plants were grown at a temperature of 55°F (12·8°C) dropping to 50°F (10°C) approximately a fortnight before planting into two unheated structures, each approximately 1/57 acre, on 20 April. Two planting distances were tried, 9 × 9 in. and 10 × 10 in. as a solid planting with no pathways, and information was collected on the cost of each planting, using the cost of plants and the value of the man hours used on the operation. On 12 May a spray of prometryne at 1.0 lb a.i. per acre as 2.0 lb Gesagard 50 per cent wettable powder was applied, and this very successfully controlled all weed growth until the plants were sufficiently well grown to smother any later germinating weeds. Watering was by means of overhead spraylines and apart from the application of water when necessary, the crop received no further attention until lifting. This operation started on 5 July and was completed a week later; the quality was good with 99 per cent of the heads marketable. At this period there was a good demand for the crop and gross market returns of 1s. to 1s. 6d. per head were obtained.

Using the actual crop yields and gross market returns for 1967, it was calculated that the 9 in. square planting produced a gross return equivalent to £4,137 per acre, an increase of £740 per acre over the 10 in. square spacing. The cost of producing the closer planted crop was, however, greater, but with plants and planting costs at approximately £52 per acre extra and an allowance for increased marketing costs, the 9 in. spacing still gave a more economic return.

With any crop in glasshouses it is important that it should fit into a rotation so that the house is used to its fullest capacity. Self-blanching celery in the West Midlands fits into a rotation of spring lettuce, celery, autumn maturing lettuce or late planted chrysanthemums and provides a useful alternative to tomatoes, where intensive cropping has produced a build up of root diseases and consequent loss of crop.

Work on this crop is to be continued, with more emphasis on planting dates, to give continuity of crop.

EARLY POTATOES: SOURCES OF SEED

L. M. Gill, *Rosewarne Experimental Horticulture Station*

Following discussions with local growers and county advisory staff, it was felt that there was a need to study the effects of planting seed potatoes of known history from a number of sources. A randomized block experiment was started at Rosewarne in 1967, and will be continued for two further years, with the object of observing the yield at four lifting dates of two varieties, Arran Pilot and Home Guard, from six different sources, Northern Ireland—early lifted and late lifted, Rosewarne, Scotland, North Cornwall and Wales. It was only possible to obtain Home Guard from the source in Wales.

It was not feasible to expect the seed potato growers at the different sources to plant, burn-off and harvest on the same date due to varying climatic conditions, but the dates on which these operations were carried out were supplied by the growers, so that the history of each stock is known.

Each stock of tubers was stored in the same conditions on arrival, but dates on which they were received varied from mid-October to mid-November.

Tubers of equal size and weight (2½ oz) were set up in wire trays and sprouted in a glass chitting house, ventilated well during the day and thermostatically controlled to a minimum temperature of 40°F (4·4°C) during the night.

Both varieties from most of the sources had sturdy sprouts 1–2 inches long at planting time, except for 'Arran Pilot' (N. Ireland—late lifted) which were shorter. Planting took place on 2 March when soil temperatures were a little below 45°F (7°C).

First emergence was noted after an 11-degree ground frost on 31 March, but below average soil temperatures and a dull, cold and fairly dry April, delayed growth and bulking by 10–14 days. From first to full emergence took 5 weeks. 'Home Guard' emerged a little in advance of 'Arran Pilot'. 'Arran Pilot' (Scotland) was the only source noticeably behind on 13 April.

It has been the usual practice at Rosewarne, where there have been several lifting dates within an experiment, to lift 10–14 days earlier than general commercial liftings in the area so that any treatment differences could be detected at an early stage. Four lifts at weekly intervals were carried out and the crop graded, ware tubers being those retained by a 1¼ inch riddle.

The first lift was on 23 May when 'Home Guard' (Rosewarne) produced the heaviest weight of ware at 1 ton per acre, 'Arran Pilot' (Rosewarne) ¾ ton ware per acre and 'Home Guard' (N. Cornwall) ½ ton per acre—only slightly better than 'Arran Pilot' from the same source.

At the second lift, 'Home Guard' (N. Cornwall) yielded 2½ tons and 'Home Guard' (Rosewarne) 2¼ tons per acre.

At the third lift 'Home Guard' (N. Cornwall) yielded 5 tons and 'Home Guard' (N. Ireland—seed late lifted) 4¾ tons.

At the fourth and last lift, 'Arran Pilot' (N. Ireland—early lifted) produced 7½ tons, but other sources of 'Arran Pilot' and 'Home Guard' (N. Cornwall) were only ½ ton less; all other sources of 'Home Guard' were 1–2 tons less.

It was noticeable at each lift that 'Home Guard' (Wales) ware and total yield was ahead of 'Home Guard' (Scotland), and compared quite well with all sources of 'Arran Pilot' until the last lift when the ware was one ton less.

Total yields of 'Arran Pilot' from all sources were well ahead of 'Home Guard' at the last lift except for N. Cornwall which were reasonably comparable.

Comparison of Yields of the Two Northern Ireland Sources

Total weights

There was no significant difference between 'Arran Pilot' early lifted and late lifted, but both were significantly better than 'Home Guard' from both sources except for 'Arran Pilot' (late) at the first lift.

Ware weights

'Arran Pilot' early lifted was significantly better than 'Arran Pilot' late lifted, but 'Home Guard' (late) was significantly better than early lifted at the last two lifts.

Varieties

There was no significant difference between varieties from the early lifted source until the final lift when 'Arran Pilot' was better than 'Home Guard.'

From the late lifted source, 'Home Guard' was significantly better than 'Arran Pilot' at the first three lifts, but at the last lift the position was reversed.

Monetary Value of Crop Lifted

The table gives the calculated value of the crop in £ per acre on the four lifting dates for each variety and source of seed. The values have been calculated using the following 1967 prices for early ware potatoes (£ per ton):

24 May	31 May	7 June	14 June
Channel Islands	Channel Islands	Rosewarne	Rosewarne
£112	£112	£86	£67

Calculated value of the crop lifted (£ per acre)

Variety and source	Date of lifting			
	23 May	30 May	6 June	13 June
Arran Pilot:				
N. Ireland—early lifted	26	188	337	498
N. Ireland—late lifted	9	164	323	466
Rosewarne	72	197	367	469
Scotland	28	140	332	483
N. Cornwall	45	184	346	476
Home Guard:				
N. Ireland—early lifted	26	199	305	344
N. Ireland—late lifted	35	214	408	413
Rosewarne	108	243	335	340
Scotland	31	190	342	368
N. Cornwall	64	293	443	476
Wales	35	225	344	407

It would seem, from previous observations and this year's results at Rosewarne that considerable expense on carriage could be saved by growing one's own seed (in isolation) or obtaining North Cornwall seed. Earlier delivery would enable growers to plant well sprouted seed. Combined with correct manuring and early planting of large seed a worthwhile ware crop could be lifted in late May or early June in a good season.

RAISING EARLY SUMMER CAULIFLOWER PLANTS IN CLOSED DUTCH LIGHT FRAMES

J. D. Whitwell, *Kirton Experimental Horticulture Station*

A few specialist plant raisers of early summer cauliflowers in Holland, Lincs, overwinter the crop in Dutch light frames without ventilation. The seed is sown in frames in late September in rows 3in. apart, using small precision seed drills capable of spacing the seed approximately 1 in. apart in the rows. After this operation the Dutch lights remain closed until the plants are hardened off in March. Air movement takes place through cracks between the frames and at the points where the lights rest on the side and ridge boards.

This system lowers the cost of plant raising appreciably and it was therefore thought essential to evaluate the method in an experiment at Kirton so that its effect on seedling stand and size could be determined.

The variety 'Delta' was sown in compartmented double-span frames on 5 October, 1966. Each compartment consisted of two Dutch lights, one with a covering of UC (University of California) compost 2in. deep over the border and one without. After drilling the seed, six of these compartments were closed down and left without ventilation and six were ventilated as considered necessary throughout the winter months. A summary of the results obtained is given in the table.

Comparison of Plant Counts in Ventilated and Non-ventilated Dutch Light Frames

Rooting Medium	Number of seedlings per single Dutch light, 8 November			Number of plantable plants, 8 March			Plants available on 8 March of those present on 8 November per cent			Plants below average size, 8 March per cent		
	Vent	No Vent	M'n	Vent	No Vent	M'n	Vent	No Vent	M'n	Vent	No Vent	M'n
Soil	293	315	304	186	204	195	63·8	65·3	64·5	39·3	35·4	37·4
Soil+2-in. cover of UC	225	265	245	154	186	170	67·7	70·4	69·0	46·9	17·8	32·4
Mean	259	290	275	170	195	182	65·7	67·8	66·8	43·7	26·6	34·9

In the initial count taken on 8 November at a time when most of the seeds had germinated, there were more seedlings in the non-ventilated frames than in the ventilated. This position was maintained up to the time when the plants were ready for transplanting on 8 March, when the percentage of plantable plants, expressed as a percentage of those counted on 8 November, was the same for both ventilated and non-ventilated frames. This proved that the losses over winter were no greater in the non-ventilated frames. The plants were graded for size at transplanting time, and the proportion of plants below average size was lower in the non-ventilated frames, particularly those grown on the 2in. layer of UC compost.

REDESDALE EXPERIMENTAL HUSBANDRY FARM

This large hill farm has recently been taken over by the N.A.A.S. (see the list of centres given on page 94). This view shows Cleughbrae farmstead with part of the hill behind.

BOXWORTH EXPERIMENTAL HUSBANDRY FARM

Minimum cultivations for cereals

Stubble on a direct-drilled ('slit-seeded') plot beside a ploughed one (see page 31).

PLATE I

HIGH MOWTHORPE EXPERIMENTAL HUSBANDRY FARM

Maincrop potato seed storage
Chitting outdoors under polythene (see page 3).

TERRINGTON EXPERIMENTAL HUSBANDRY FARM

Cultivation systems for maincrop potatoes
Section of a ridge in a crop grown on the Dutch system on a silty loam. There is a clear division between the tilthy part of the ridge where the tubers are growing and the unworked soil below (see page 29).

PLATE II

HIGH MOWTHORPE EXPERIMENTAL HUSBANDRY FARM

Chilled grain storage

The experimental unit, showing return duct taking air from the top of the 'on-the-floor' store (see page 35).

DRAYTON EXPERIMENTAL HUSBANDRY FARM

(Photo: M V. Jackson)

Chilled grain storage

A mobile unit without a return duct connected to a bin (see page 35).

PLATE III

TRAWSCOED EXPERIMENTAL HUSBANDRY FARM

(Photo: by kind permission of the Farmers' Weekly)

Winter housing for sheep

Ewes in specially built sheds (see page 56).

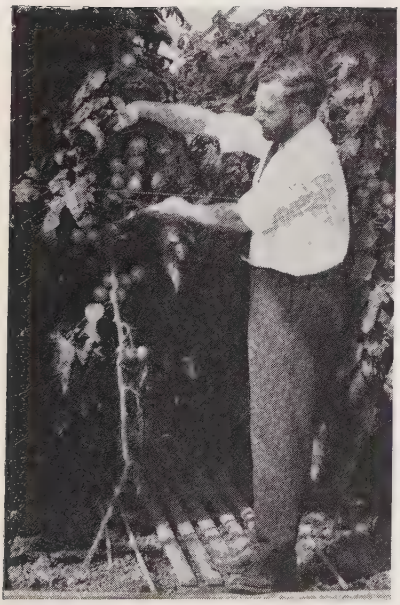
ROSEMAUND EXPERIMENTAL HUSBANDRY FARM

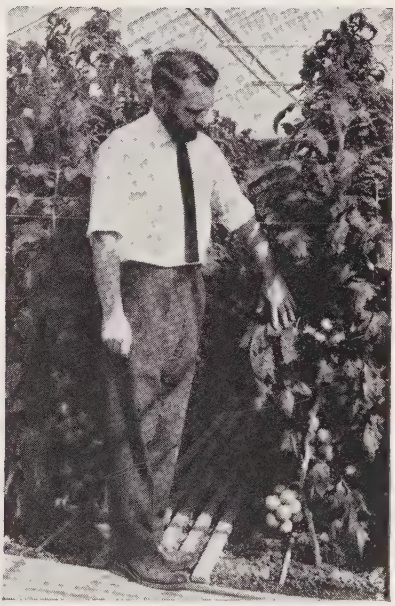
(Photo: by kind permission of The Hereford Times)

Winter housing for sheep

Ewes housed in an existing building (see page 56).

PLATE IV





Growing early tomatoes (see page 19).

1. Blueprint (L) and traditional (R) on 19th January
2. Blueprint (L) and traditional (R) on 6th February
3. Blueprint on 14th April
4. Traditional on 14th April

PLATE V

EFFORD EXPERIMENTAL HORTICULTURE STATION

The regulated hedge system of growing dessert apples—note excellent growth of the trees and the use of herbicides within the rows leaving an 8 ft grass strip in the alleys.

LUDDINGTON EXPERIMENTAL HORTICULTURE STATION

Scald affected fruit of Bramley's Seedling after storage in bulk bins lined and covered with polythene sheet (see page 73).

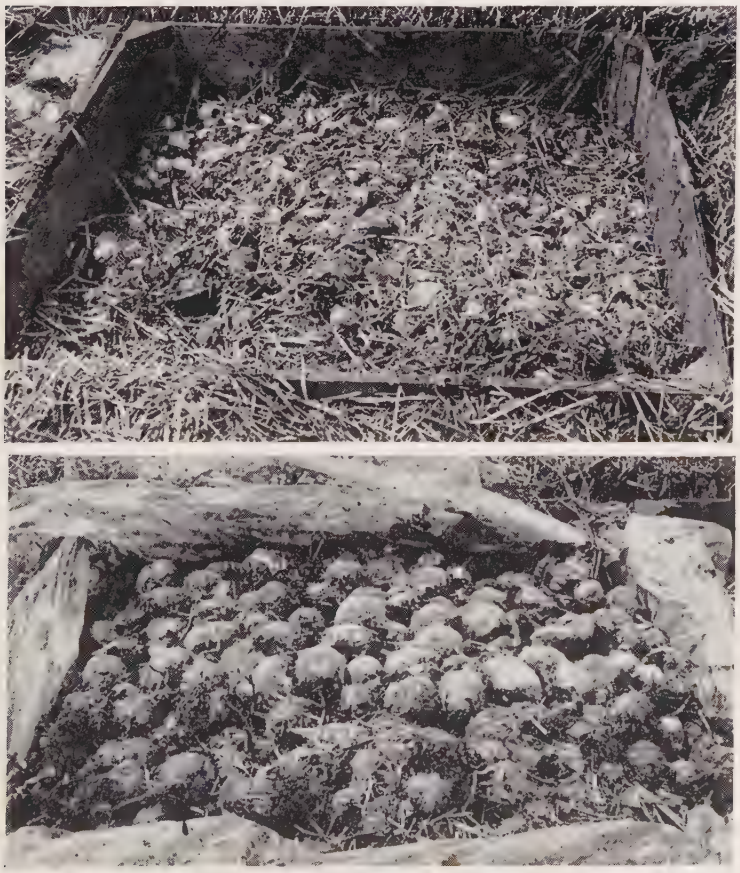
PLATE VI

ROSEWARNE EXPERIMENTAL HORTICULTURE STATION

Factors affecting flower life of narcissus

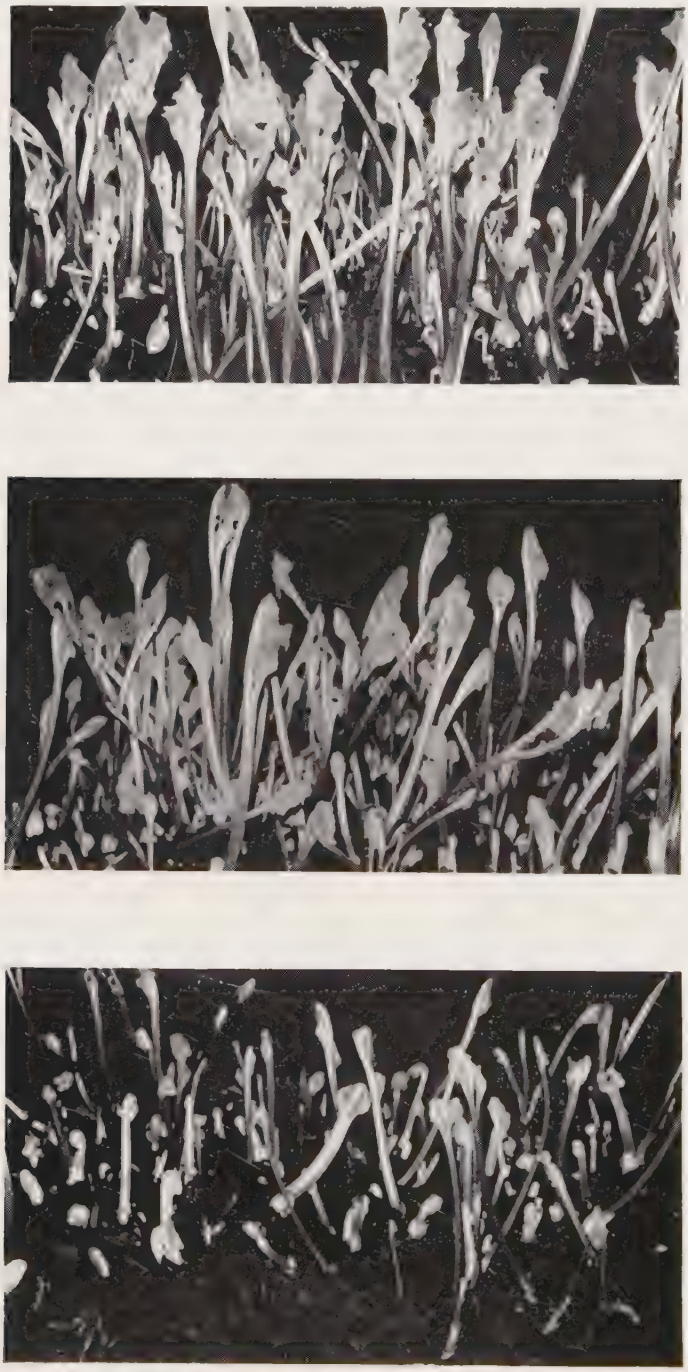
Narcissus packing: ideal stage of development at picking for five types of narcissus. (L to R) trumpet, poeticus, double, small cup, large cup.

LUDDINGTON EXPERIMENTAL HORTICULTURE STATION



Beetroot storage, bulk bin in bale clamp (upper) bin not lined (lower) bin lined with polythene. Note desiccation leading to large loss of volume in unlined bin. Photographed July 1967

PLATE VII



Forcing of rhubarb after treatment with 100 mg gibberellic acid (upper) 50 mg gibberellic acid (centre) compared with the control (see page 61).

PLATE VIII

When these plants were grown on in the field, it was noted that there were no significant effects between the treatments in terms of yield, head quality, and head size. The plants grown in 2in. of UC compost matured slightly later than those grown in the soil border.

It has thus been shown that the cost of overwintering direct drilled early summer cauliflowers in double span Dutch light frames can be lowered by keeping the frames closed after drilling. Plant survival is as good in closed frames as in ventilated ones, and there is a positive increase in plant size at planting time, particularly when the seeds are sown in a 2in. layer of compost spread over the soil border.

CONTROL OF DOWNY MILDEW ON SEEDLING CAULIFLOWER

J. D. Whitwell, *Kirton Experimental Horticulture Station*

Downy mildew (*Peronospora parasitica*) is a perennial problem in seedling cauliflower production in the Holland division of Lincolnshire, especially in the autumn sown crop which is overwintered under glass for planting out in the spring.

In a trial carried out in 1966, seedlings of the early summer cauliflower variety Snowball A.H.291 were sprayed with five different fungicides on eight occasions between seedling emergence and the fully expanded true-leaf stage. The first spray was applied on 3 October, the day the first germinated seed was visible, and further sprays on days 3, 7, 11, 18, 25, 32, and 39 after the initial spraying.

The following table gives the results from the two best treatments and also the unsprayed control:

Treatment	Infected plants		Plant size and dry weight		Plant stand	
	17 Oct.	14, 15 Nov.	Average length of first true leaf in mm	Average dry weight of tops in g 15 Nov.	per 20ft run of drill 14 Oct. 1966	per Dutch light 10 Mar. 1967
	per cent					
Dichlofluanid	4·6	67·2	60·0	2·36	275	248
Propineb*	5·3	69·5	57·1	2·21	288	217
Control—unsprayed	20·4	91·6	43·0	1·24	300	174

*This crop was treated with propineb for experimental purposes only. This use of propineb has not been considered under the Pesticides Safety Precautions Scheme, consequently no advice can be given on its safe use for this purpose. In the absence of such advice brassicas should not be treated with propineb.

The results show that dichlofluanid and, to a lesser extent, propineb, can protect the young plants from infection and it is probable that a larger and more vigorous plant is produced as a result of the treatment. The most significant result obtained was the increase in plant population which, in

economic terms, may be interpreted as a substantial return from the investment of spray materials and labour. The results are from a single year's trial only in the case of propineb, but a similar result was obtained with dichlofluanid in a trial conducted in the autumn of 1965.

CONTROL OF CELERY LEAF SPOT BY THIRAM SOAK TREATMENT OF SEED

R. B. Maude, *National Vegetable Research Station*
M. B. Wood, *Stockbridge House Experimental Horticulture Station*

Septoria leaf spot infection of celery seed was, for a number of years, thought to be adequately controlled by hot water treatment. Recently this has been found not to be the case, and small outbreaks of the disease have occurred amongst plants raised from treated seed. Various alternatives to hot water treatment have been compared in experiments carried out by the Pathologists' Department at the National Vegetable Research Station and the following treatment has been found to give 100 per cent control of *Septoria*.

Seed is soaked in a 0·2 per cent thiram suspension for twenty four hours at a temperature of 30°C (86°F), after which it is dried by passing a high volume of air through it at lower temperatures (20–25°C 68–77°F).

Plants raised from seed treated by the normal hot water method were compared for quality with plants raised from thiram treated seed in experiments carried out in 1966 and 1967 at Stockbridge House, and at a holding on the Methwold Fen in Norfolk. In both of the Stockbridge House experiments there was a slight difference in yield in favour of the thiram treatment. For instance, in the 1967 experiment, thiram soaking produced an increase in the proportion of sticks in the larger grades. At Methwold there was a greater difference favouring thiram, but this trial was not replicated. However, the main fact to emerge is that the thiram soak has no adverse effect on seed germination or on the yield of the subsequent crop. The trials at Stockbridge House have been conducted in years when *Septoria* has been absent and no doubt the main benefit of a thiram soak will be seen in years when the disease is prevalent.

In addition to its use to control celery *Septoria*, the treatment has also been tested on other seed-borne diseases. It has been shown that many of the diseases of a range of vegetable and flower crops can be eliminated from the seed by this means, but a few diseases are either not controlled or only partially so by this treatment. It has been found that some flower seeds are sensitive, and the treatment may have to be modified in these cases (e.g., Lobelia seed is treated for twelve hours only). Pilot tests should be made before treating bulk quantities of seed.

The eventual commercial use of the thiram method depends on many factors, e.g., size and ease of handling of soaked seeds, tonnage to be treated etc. It is already apparent, however, that the treatment is commercially acceptable for small and valuable seeds and it is being taken up by several seed merchants.

SPACE DRILLING OF LETTUCE

Jean M. Garthwaite, *Luddington Experimental Horticulture Station*

Natural lettuce seed, being elongated in shape, cannot be spaced out at drilling when using the types of space drills which demand a round or almost round seed of uniform size. With a normal lettuce drilling, therefore, the seedlings have to be both thinned out and singled to give the required final spacing in the row. It is possible, however, to obtain lettuce seed encased in rounded clay pellets and with pelleted seed any spacing pattern can be drilled.

For two years spring and summer crops were drilled at Luddington E.H.S. comparing different spacing regimes. A belt feed selector type space drill was used and all drillings were in a bed system comprising five rows with one foot between each row. The three spacings compared were 2 inches and 6 inches in continuous lines and a patterned treatment of two seeds 3 inches apart with a 6 inch spacing between each pair of seeds. In three of the four trials a fourth treatment, using unpelleted seed in a continuous braid, was also drilled.

The varieties used in the experiments were Trocadero 18,920 pellets per lb in 1966 and Trocadero Improved, 17,800 pellets per lb in 1967 for sowing in late March and harvesting at the end of June. For late July drilling Cobham Green, 26,370 pellets per lb, was used in 1966 and Mildura 6,250 pellets per lb was used in 1967. These crops were for harvest in October.

The reasons for the great difference in number of pellets per lb between the summer 1967 seed and the others was that one brand of pellet was small and soft but rather irregular in size and was used because it was the cheapest form of pellet. This type is no longer available as it was changed for a larger, harder one during 1967 so there was no longer any advantage in choice of pellet. In 1968 a new form of small pellet is being produced which may further reduce seed costs.

The yields from the various drilling treatments have not been widely different; in the two 1967 trials they were slightly in favour of the 6 inch spacing but in 1966 this treatment was a little below the others. This may have been due to the closer spacings being thinned to slightly less than the intended one foot in the row. The thinning was carried out, as in commerce, without measuring and thus the final population was higher than intended. No herbicides were used in the trials and inter-row cultivations were mechanized, but row hoeing and chopping out were timed. In three out of the four trials the 6 inch and 3 in. + 6 in. spacings took less time to work and were therefore the cheapest to maintain. In the fourth trial there was little difference between treatments.

Obviously the 6 inch spacing used the least amount of seed and the amounts and cost of this for the various summer 1967 drilling treatments were:

2 inch spacing Pelleted Mildura (6,250 per lb) 34 lb per acre at 17s. 6d. per lb = £29 15s. 0d.

6 inch spacing Pelleted Mildura (6,250 per lb) 11¼ lb per acre at 17s. 6d. per lb = £9 18s. 0d.

3 + 6 in. spacing Pelleted Mildura (6,250 per lb) 17 lb per acre at 17s. 6d. per lb = £14 17s. 0d.

Unpelleted Mildura (421,000 seeds per lb) 3½ lb per acre at 78s. per lb = £13 13s. 0d.

There was no difficulty in obtaining a good germination from pelleted seed in any of the trials but in all cases the land was irrigated to bring it up to field capacity before final cultivations because it is essential that sufficient moisture is present in order to get even germination of pelleted seed. The 6 inch spacing was found to be the most economical spacing to adopt and its advantage would probably be greater if it were combined with a good herbicide which did not check the growth of the lettuce.

VARIETIES OF SWEET CORN

B. Ebert, *Luddington Experimental Horticulture Station*

The introduction of some interesting hybrid varieties of sweet corn from North America, coupled with a small but steady increase in fresh market sales, has resulted in a reappraisal of this crop. The quantity of sweet corn frozen by the processors is small but an increase in demand in the fresh markets could increase out of season demands. Factory capacity at a peak time is probably the greatest limiting factor with the processor, who has preferred to import his requirements from abroad.

The performance of 6 commercially available varieties and 2 from the Vineland Station, Ontario were compared at Luddington in 1967. Particularly with this crop, market demands are for a continuity of supply without peaks. This is best obtained by using a selection of varieties. Staggered outdoor sowings of the same variety do not achieve this end. Market requirements are for cobs of at least 5 inches in length, with straight and complete rows of seed of a pale yellow colour. Dark yellow seeds tend to give the harvested cobs an overmature look which detracts from their appearance. Good cob fertilization requires high temperatures, and varieties more tolerant of British conditions, yet still with a good flavour, are required.

Yields of 1–2 cobs per plant need improving. Yields can be increased by closer plant spacing and varieties not prone to tillering are to be preferred. Strong stems are essential if the crop is grown in an exposed site. At Luddington a large proportion of the variety 'North Star' was snapped off at ground level in a gale in early September while adjacent varieties were unscathed.

Seed was direct drilled at Luddington on 24 May. Polarvee was the first variety to mature but the cobs were too small and poorly fertilized at harvest. There is still a need for a good mid-August maturing variety. Polarvee sown outside at Rosewarne E.H.S. (Cornwall) on 8 May did not mature until 4 September, suggesting that the mean summer temperatures for the south-west are too low for quick maturity.

The table illustrates the performance of the varieties grown at Luddington; this is only a selection of those under test at various centres by the National Institute of Agricultural Botany.

Variety	Date of first harvest	Marketable cobs per 100 plants	Grain colour	Mean degree of filling 0=Poor 5=Good
Polvaree	August 17	49	Yellow/orange	2·1
Buttervee	August 30	117	Cream	2·9
Early King	August 31	114	Deep cream	2·5
Canada Cross	August 31	101	Deep cream	2·8
North Star	September 8	130	Cream	3·6
Northern Belle	September 14	212	Cream/gold	3·3
Kelvedon Glory	September 15	176	Cream	3·3
October Gold	October 12	192	Golden	3·6

DE-LEAFING OF MIDSEASON BRUSSELS SPROUTS

P. B. Tatham, *Efford Experimental Horticulture Station*

Broken leaf stalk bases, which remain firmly attached to Brussels sprouts stems after de-leafing, often cause frustrating delays during subsequent stripping by sprout stripping machines. De-leafing in advance of actual harvest is thought to help by allowing time for these persistent stubs to senesce and fall off naturally. But this practice may lead to considerable loss in yield. In the 1967 issue of this publication (page 56) it was reported that serious losses. could be expected when prior defoliation was done on early maturing crops of 'Early Half Tall', which were still growing vigorously at the time. At Efford in 1966 and 1967, the effect of de-leafing on a cross-section of main season Brussels sprouts varieties was looked at in fully replicated experiments.

In 1966 sowing was done 1 March, planting 13 May and harvesting on 1 November. In 1967 the dates were 6 March, 18 May and 6 November.

Effect of defoliation: marketable yield

Defoliation: days before harvest	Tons per acre	
	1 November 1966	6 November 1967
14	5·1	5·2
7	5·9	5·3
Same day	5·8	4·8

In spite of the apparent fall in yield following de-leafing 14 days before harvest in 1966, analysis of the data for both years reveals that the differences are not significant and are most likely due to chance. It thus seems safe to conclude that by November any remaining leaves are contributing little to the yield of main season Brussels sprouts which have reached maturity during the fortnight before harvest. It is therefore suggested that de-leafing can be

carried out at any time in this period, and certainly within a week of harvest, without prejudicing yield. The position may be different with late varieties harvested at this time before they are fully mature.

The advantage of advance de-leafing may be little more than one of convenience at this time of year, when the stems have hardened up and machine stripping generally becomes much easier. This contrasts with the position earlier in the year when stems are soft and leaf bases young and fleshy, and resistant to breakage. At this time the advantages may be real and trials are now required to cover the period around late September-October when the value of easier machine stripping, following early de-leafing, can be equated with any expected yield losses, and the practice assessed in economic terms.

STORAGE OF MAINCROP BEETROOT

J. R. Chrimes, *Luddington Experimental Horticulture Station*

Experiments are being carried out at Luddington E.H.S. to find satisfactory methods of storing main-crop beetroot until a new crop is ready. The first two years of the three year trial have shown promising results.

The main part of the experiment has been a combination of various clamp types followed by cold storage. For comparison, beet have been left in the field over winter, either earthed up or with straw spread between the plants at the rate of 5 tons per acre. In the mild winter of 1966–67 these treatments proved satisfactory, but in the previous winter very severe losses occurred, and beet stored this way will bolt by late April.

In both years of the investigation, the seed was sown in early July and the crop pulled in early November; the varieties were Detroit Globe in 1965 and Crimson Globe in 1966. The beet were lifted and cleaned by hand then clamped in the open field until early April. Half the clamped beet were then cleared, roots removed, and the sound beet placed in a cold store run at 35°F (1·7°C). The remaining beet were left in the clamps. Clamps and cold store were cleared for a final rot assessment in late May of 1966 and in early July for the 1966–67 experiment.

Various types of clamp have been compared over the two seasons. Each was 14 ft long and 4 ft wide holding about 2 tons of beet. An orthodox type of clamp using a 6 in. layer of straw covered with soil over the piled beet, was compared with different types of straw bale compound. Beet were placed inside single bale walls and the ridge covered with sloping bales, the beet either being loose or contained in 43 in. square wooden bulk bins.

Ventilation tended to be excessive when using bales, and rather severe desiccation occurred by July. In the second year, a 500 gauge polythene lining was placed between the loose beet and the bales, and in half of the bulk bins.

For cold storage in both years, beet were placed in 21 in. well-based bins with sides and base lined with 150 gauge polythene to keep them clean for future apple storage.

Percentage of original weight of beet still marketable after storage (1967)

Type of clamp	Ex-clamp		Clamped until 5 April, ex-cold store 4 July
	5 April	7 July	
Orthodox field clamp	97·4	60·0	92·2
Bales—bulk bins, lined	97·3	90·0	97·0
Bales—bulk bins, unlined	96·3	45·5	77·4
Bales—loose beet	96·3	77·0	84·0
Bales—loose beet—polythene lined	98·5	60·0	87·5
Mechanically loaded into bins from clamp			86·7

It can be seen from the table that by April 1967 little rotting had occurred in any clamp. Some shrivelling of the beet had started in the unlined straw bale clamp and bins, and losses from this cause were severe by July. However, beet in the lined straw bale clamps were in an extremely good condition in April as were beet kept in lined bins.

Rotting was proceeding in all clamps by July 1967 but was least in the straw bale compounds containing lined bins or loose beet. Cold storage from April to July gave somewhat better results.

Additional investigations in cold store showed that increasing depth of bin up to 30 in. made little difference in keeping quality of beet, nor did cleaning the beet prior to cold storage. Lining the bins had little effect, but covering the top with polythene did decrease rotting and water loss. Mechanical loading of beet direct from the clamp into bins, using a tractor-mounted manure loader, also appeared to have little effect on the subsequent amount of rotting.

In the 1967–68 season, larger straw bale clamps are being investigated. The width of the lined and unlined loose beet clamps has been increased to 9 ft. A separate 18 ft wide bale clamp has been constructed with double bale walls 3 ft 6 in. high. Polythene sheeting has been placed between the bales. To aid ventilation, lengths of 1 ft diameter drain pipe were laid along the centre of the floor before the clamp was filled.

Results to date have shown that:

(a) prolonged storage in the field is unreliable;

(b) clamps are cheap and satisfactory until April, but wastage increases rapidly afterwards in some seasons;

(c) lining the clamp with polythene reduces desiccation and in early April the beet were in very good condition, but the experimental clamp was small and further work is required;

(d) in early July the highest percentage saleable from clamps was found in polythene lined bulk bins housed in straw bales. Estimates of additional capital cost have been made. Assuming a bin lasts six years and it is lined with polythene, it would cost £1 15s. 0d. to £2 10s. 0d. per ton of beet per year according to size of bin. If the bins were used for other crops when not required for beet, the cost would be reduced.

(e) cold storage at a temperature of 35–36°F (1·7–2·2°C) was satisfactory until July.

The cost of electricity for running the cold store at Luddington is approximately 6d. to 7d. per ton per week at 1½d. per unit. Cost of bins and depreciation on the cold store must also be borne in mind.

New Items of Interest in the Experimental Programme

PHOSPHATE AND POTASH FOR CONTINUOUS CEREALS

In the late nineteen forties, many soils were low in available phosphorus and potassium. Subsequent moderately heavy use of fertilizers has improved large stretches of land and there is now increasing interest in more economical methods of fertilizer application aimed at maintaining suitable levels of phosphorus and potassium in the soil, so that shortage of either does not limit yields in future.

Advisers must build up knowledge of the behaviour of phosphorus and potassium in various soil types, so that they can accurately plan 'maintenance' fertilizer policies appropriate to the full range of farm situations. With this in mind, a series of experiments has been started at High Mowthorpe and Gleadthorpe and on various commercial farms on different soil types throughout the country. At each site, nil, 40, 80 and 120 units per acre of P_2O_5 or K_2O are applied to separate plots year after year, under continuous cereal cropping. These rates should result in some run-down, maintenance, a moderate build-up and a large build-up in the soil reserves of P and K. These trends will be recorded by annual measurements of yields and crop composition and periodic soil analyses. When clear differences between the soils have been produced, the main plots will be sub-divided and a range of rates of P or K will be compared within each one. At the same time, it is possible to take large samples of soil for pot experiments and smaller ones for soil analytical investigations.

The lack of response to combine-drilling of phosphate and potash, now experienced on many farms with a back-history of adequate manuring, has prompted farmers to wonder whether drilling operations can be speeded up without loss of yield, by leaving out P and K dressings altogether at this stage and relying upon maintenance rates applied in bulk every few years by contractors operating outside the growing season. This subject is now being studied at two E.H.Fs.

An experiment was started at Boxworth in 1965 to compare annual dressings of phosphate as superphosphate and basic slag with the same total amounts of the fertilizers applied once every five years. Yields will be followed through an arable rotation. In 1966, an experiment on continuous cereals was started at Bridget's comparing annual dressings of superphosphate with a similar total amount applied once in three years. A similar experiment with potash was started in the same year.

PRESERVATION OF HAY BY CHEMICAL ADDITIVES

Chemical preservation of hay baled at the barn drying stage could obviate the expense of artificial drying or alternatively reduce the drying period in the field and therefore the risk of loss through rain damage.

In 1967 a small scale trial was laid down at Drayton E.H.F. to test the efficacy of four additives in suppressing the development of bacteria and moulds in hay baled at 30–35 per cent moisture. Two proprietary compounds, formic acid and propionic acid were tested. The proprietary compounds were applied in accordance with the manufacturers' recommendations and the two organic acids at 2 per cent by weight. Microbiological examination was carried out before treatment and at regular intervals afterwards. Temperatures were recorded at the same time. Moulds developed superficially in all treatments and there was some heating in all treatments. Unfortunately a final assessment was not possible, as all this hay had to be destroyed following the outbreak of Foot and Mouth disease on the farm.

A small scale trial was also laid down at Trawscoed E.H.F. in which one additive was tested.

In 1968 it is planned to carry out further investigations at Drayton, Trawscoed and Great House E.H.F.s.

CONTROLLED ENVIRONMENT HOUSING FOR CALVES

Young farm animals differ in their ability to cope with the varying climatic conditions they encounter during the course of their early life.

Piglets are the least well catered for by nature and much research has been carried out to find the optimum conditions under which they will thrive, but little attention has been paid to the heat and ventilation requirements of beef calves.

Over the last three years, some work has been carried out in converted buildings at Drayton and High Mowthorpe E.H.Fs. The results, in terms of performance, liveweight gain and food conversion, have been somewhat variable and it has not always been possible to define exactly the conditions under which the results were achieved. Consequently it was decided to build two controlled environment calf houses, one at Drayton and the other at High Mowthorpe, to examine the factors which go to make up the optimum condition of temperature and ventilation for successful calf rearing.

Both houses have been built to a common design and consist of four insulated compartments (each large enough to house twelve calves) in which temperature and ventilation can be controlled, and a Yorkshire boarded unheated area with natural ventilation, where calves can be reared in straw bale kennels. There is a food store and preparation room in which the control equipment is also housed.

The four controlled environment compartments are carefully insulated on all sides, top and bottom, giving the same degree of insulation as an 11 in. cavity brick wall with the cavity filled with foamed plastic. Inlet and extraction fans provide the ventilation and, with a total capacity of 1500 c.f.m. each, are capable of a range of 4 to 30 changes of air per hour. Each of these compartments is fitted with a heater bank of 4 kW capacity, which is brought into operation automatically whenever the temperature in the

compartment falls below the chosen level, and is shut off when the temperature rises more than two or three degrees above the level. Ventilation is controlled manually in two compartments and electronically in the other two. An automatic recorder continuously measures temperatures, relative humidities and air speeds to provide an exact record of the position in each compartment at any time.

Records of liveweight gain, food consumption and health, are being kept for each calf. Both houses were commissioned in the autumn of 1967 and the first ten weeks rearing period was used to 'run in' the equipment, familiarize the staff with the control and recording system, and to sort out any snags. Temperature control has been limited to the maintenance of chosen minimum temperatures rather than complete air conditioning.

It is planned to put three intakes of calves through during the colder months of each year to make the maximum use of the facilities.

MIXED STOCKING WITH BEEF CATTLE AND SHEEP

So far attempts to increase stocking rates of beef or sheep at grass to really ambitious levels have usually resulted in reduced levels of individual animal performance. Consequently there has been failure to achieve the rates of liveweight gain required to allow the animals to be sold fat off grass, or to enter the following in sufficiently forward condition to fatten quickly and cheaply. Hence the financial margin per beast has been depressed to such a level that increasing stocking rates beyond about three 6–12 month old beef cattle per acre, for example, has not given worthwhile gains in total returns per acre.*

The problem has been due to various causes, possibly including parasites and reduced appetite for grass caused by fouling, perhaps in combination with other factors that are not yet clearly identified. The measures that may eventually prove to be necessary to overcome this difficulty might turn out to be complicated and expensive, and may require an exceptionally high level of management expertise on the part of farmers. This suggests that, in addition to investigating this problem, the Experimental Husbandry Farms should also explore other possibly easier ways of achieving high output profitably from grass. Mixed stocking with cattle and sheep has possibilities in this direction: a high total stocking rate in terms of livestock units per acre may be achieved by adding together only moderate separate stocking rates of each class of stock. This may be a means of 'diluting' the levels of parasites specific to each type of animal and diminishing other problems similarly, to allow high levels of animal performance to be obtained.

An experiment has been started at Trawscoed to detect whether benefits really will occur. Cattle alone, cattle with sheep, and sheep alone are being grazed at two standard total stocking rates measured as livestock units per acre. Thus there are 6 separate grazing areas, each carrying a group of livestock, as follows:

*See the article on nitrogen and stocking rate for grazing beef cattle on page 16.

Beasts per acre

Cattle	Cattle and Sheep	Sheep
3 heifers	1½ heifers + 4½ ewes	9 ewes
2½ heifers	1¼ heifers + 3¾ ewes	7½ ewes

The cattle are beef-type yearling heifers weighing 500 lb at spring turnout; the ewes are Welsh Half-breds with a lambing percentage of 150 and are tupped with a Dorset Down ram.

The grassland is a ley with over 70 per cent perennial ryegrass. There are six paddocks in each treatment which are rotationally grazed for 3½ days each. The grass receives six dressings of 50 units N per acre and surplus grass is conserved. The ewes are in-wintered and fed the conserved material until there is sufficient grass for the ewes and lambs to return to the paddocks.

SEASON OF CALVING AND MANAGEMENT OF BEEF SUCKLER HERDS

It is becoming increasingly evident that large scale changes in upland suckler herd management are required to achieve more attractive returns. Observations and trials over the last three years at Trawscoed indicate that Hereford cross Friesian dams produce and rear heavier calves than do Hereford dams similarly managed. It is also appreciated that herds with different calving patterns will vary in production costs and in the value of the weaned calf. These aspects are now being examined at Trawscoed by comparing Hereford cross Friesian heifers calving in the autumn with similarly bred heifers calving in the spring. Both groups are mated to the same Hereford sire. The autumn calving herd self-feeds silage from a covered silo equipped with cow cubicles, the calves being creep fed. The spring calvers out-winter and self-feed silage from early January. Both herds are starting with twenty heifers augmented as necessary over a six year trial period to maintain this number, and graze improved hill pasture up to 1,000 ft altitude. The calves will be followed through to finishing.

THE LARGE DAIRY UNIT AT BRIDGET'S EXPERIMENTAL HUSBANDRY FARM

The dairy herd at Bridget's is to be increased to about 300 cows and, to accommodate them, new buildings have been erected. The purpose of this increase is to examine the problems associated with the management of large and intensively kept dairy herds.

In planning the unit it was decided to include automatic feeding and slurry handling, so that these could be examined thoroughly and compared

with more conventional methods. The cows are to be housed cheaply in modern-type cubicles, and the milking parlour should adopt all the latest techniques and be designed to allow labour studies and milking routines to be examined. At the same time consideration had to be given to possible future expansion of the unit to 500 cows.

The unit is therefore planned round a central parlour block to which the cows have easy access from the cubicles. Winter feeding is based on high dry matter silage stored in concrete towers and moist barley which is automatically conveyed to the cows in the covered feed area adjacent to the cubicles. Additional concentrates are fed in the parlour.

The slurry is scraped daily into a cross duct from which it passes into the slurry tank. From here it can be pumped either on to arable land or the grass.

The whole unit contains many interesting features from the buildings and construction point of view and is designed to allow experimental work to be carried out between groups of cows.

In order to facilitate the movement of cows to and from pasture during the summer grazing period, a new paddock layout has been designed. This is based on twenty one 5 acre paddocks divided by a single strand of electrified barbed wire. Access is by a corridor 40 feet wide, sub-divided along its length so that half may be rested at a time. The leys are mainly either S.23 or S.321 perennial ryegrass sown as pure swards, but some tall fescue paddocks are also included. At present two cows are carried per acre and conservation is only taken from this area in order to assist with good grassland management. Grass for conservation is grown elsewhere on the farm.

SUMMER MILK PRODUCTION

Successful summer milk production is supposedly influenced by calving date, a high stocking rate and adequate grass of high feeding value. These factors are being studied in new experiments at Trawscoed E.H.F.

Most producers of summer milk are committed to a form of grassland management which involves high nitrogenous fertilizer usage and controlled grazing which, ensures an adequate offer of young grass throughout the season. However, as levels of nitrogen usage rise, the higher stocking rates made possible tend to create a position wherein the grass on offer to the cows became tainted by the increased deposition of faeces and urine. It is generally held that this taint reaches such a degree of intensity by July that the amount of grass cows will voluntarily consume in the latter part of the season is less than that necessary for maintaining their milk potential.

As a result of such observations, some farmers have tended to graze a given area of grassland until early July and from this date to move the cows on to the aftermath of the conserved area. There is clearly therefore two alternative forms of grassland management in use:

grazing cows throughout the summer on a given area of land and conserving elsewhere on the farm;

grazing a given area of land until early July then moving cows on to the aftermath of the conserved area.

In 1967 a trial was set up to compare the productivity of these two systems. Basically the trial involves two small herds of 8 Friesian cows stocked at 0·5 acres per cow through the summer. The cows are paddock grazed on land receiving 400 units N per acre. No concentrates are fed throughout the summer. The results for 1967 did not indicate any difference in milk production per acre between the two systems, and in 1968 the trial will be repeated at a stocking density of 0·4 acres per cow.

A further trial will commence in 1968. This trial is planned to establish the influence of calving dates upon profitability. Two herds, each of twenty Friesian cows, are being set up. One herd will calve in January/February, whilst the second herd will calve in early April to match the onset of grass growth. These cows will graze at a density of 0·5 acres per cow on grassland receiving a high level of nitrogen. No concentrates will be fed during the grazing season.

ARTIFICIAL REARING AND INTENSIVE FAT LAMB PRODUCTION

Increasing the output per ewe is an effective method of improving returns from a breeding flock. However, under conventional systems of flock husbandry, a high lamb mortality can result in prolific ewes being unable to realize their productive potential. Modern techniques of artificially rearing lambs do, however, offer some promise that in the future new systems of fat lamb production can be developed to harness the potential of higher prolificacy.

Two E.H.Fs., Drayton and High Mowthorpe, are initiating studies which will provide information on the practicalities of this new approach.

On both farms the early work will be primarily concerned with the techniques of artificial rearing on a commercial scale. To begin with, conventional types of cross-bred ewes will be used, but these will be replaced by more prolific types as they become available. It would appear that the Finnish Landrace breed offers great possibilities as a crossing sire to improve the prolificacy of our native breeds, and rams have been hired from the Animal Breeding Research Organization to be used on the Husbandry Farms.

After the initial stages it is planned that the two farms will investigate different aspects of intensive fat lamb production.

At Drayton the work will be based on developing systems which involve the intensive stocking of grassland. Ewes will lamb indoors in early spring. A proportion of the lambs will remain on the ewe for a limited period whilst others are removed and reared on milk substitute, prior to early weaning. The ewes and lambs will then graze separately for most of the season, with the ewes acting as scavengers. Both ewes and lambs will be stocked at very high rates per acre, in an attempt to improve output per acre.

At High Mowthorpe, grass will play only a limited part in the system. Ewes will be housed for most of the year, and light control will be used to induce out of season breeding. All the lambs will be removed from the ewe at an early age and reared on an early weaning system, using milk substitute and concentrates. After weaning they will be fattened indoors on high energy diets.

INTENSIVE SYSTEMS OF GROWING DESSERT APPLES

There is considerable interest at present in intensive systems of growing dessert apples, and in order to evaluate several Dutch methods, small scale plantings have been made at Efford and Luddington Experimental Horticultural Stations. The main purpose of these is to gain experience in cultural and training methods prior to the establishment of larger scale plantations for detailed economic and mechanization studies. Three intensive systems are to be examined in comparison with the dwarf bush which in the past has been the most intensive system commonly planted. Although such high density plantations, up to 800 trees per acre, require a higher initial capital expenditure per planted acre compared with traditional orchards, the anticipated production of good yields of high quality fruit within a few years of planting will provide an earlier return on the capital outlay.

At both centres four dessert varieties, Cox's Orange Pippin, James Grieve, Golden Delicious and Worcester Pearmain, are to be grown on two dwarfing rootstocks under the various training systems. These systems are variations on the spindlebush and are the trained spindlebush, trained leggerspil and the groesbeck. With the first two of these, laterals are trained either all round the leader or within the row, and under the third system, which is planted at the highest density, only fruiting wood is allowed to develop from the central leader, the resulting tree thus resembles a cordon. For these systems the trees need to be supported by stakes, and with some, wiring is required in addition for the training of lateral branches. The trees are limited to a height of about 8 ft so that ladders are not needed for pruning or picking. The National Institute of Agricultural Engineering will be conducting studies in these plantations on the extent to which such operations can be assisted mechanically, and will be looking into the development of machines for this purpose prepatory to detailed mechanization studies to be undertaken later in the larger plantations.

Experimental Husbandry Farms and Horticulture Stations

Centre	*Acreage*	*Main Farming and Experimental Activities*
Arthur Rickwood E.H.F. Mepal, Ely, Cambs.	150	Arable farm on peat soils of varying depth. Studies on peat wastage. Cash crops, including potatoes, sugar beet, vegetables and cereals.
Boxworth E.H.F. Boxworth, Cambs.	858	Cereal and dairy farm on boulder clay. Intensive cropping, manuring, weed control. Break crops including beans. Feeding and management of Friesians for milk and beef.
Bridget's E.H.F. Martyr Worthy, Winchester, Hants.	1,035	Mixed farm on chalk. Cereals: intensive cropping and manuring. Break crops. Leys: fodder conservation and herbage seed production. Large Friesian herd; management and feeding studies. Intensive management of Clun and cross-bred sheep.
Drayton E.H.F. Alcester Road, Stratford-on-Avon Warwickshire.	450	Mixed farm on Lias clay. Cereals: intensive cropping; winter beans. Fodder conservation. Beef cattle: grazing, feeding and calf-rearing. Cross-bred sheep: winter housing of ewes, intensification on pasture.
Gleadthorpe E.H.F. Welbeck Colliery Village, Mansfield, Notts.	493	Light sand arable farm. Cereals: intensive cropping, manuring; potatoes, sugar beet, carrots and other cash crops; irrigation. Feeding and grazing of Friesian beef cattle. Poultry: feeding and management.
Great House E.H.F. Helmshore, Rossendale, Lancs.	460	High-lying Pennine farm in industrial area. Grassland production and utilization. Feeding and management of Friesian cattle, Gritstone sheep and Large White Pigs.
High Mowthorpe E.H.F. Duggleby, Malton, Yorks.	1,080	Mixed farm on high-lying chalk. Cereals and seed potato growing. Leys: grazing and fodder conservation. Single suckled and artificially reared beef cattle and cross-bred sheep.

Centre	*Acreage*	*Main Farming and Experimental Activities*
Liscombe E.H.F. Dulverton, Somerset.	495	Upland grass farm adjoining Exmoor. Manuring and management of grass, fodder conservation. Rearing and feeding single-suckled and artificially reared cross-bred beef cattle and sheep.
Pwllpeiran E.H.F. Cwmystwyth, Aberystwyth, Cards.	3,100	Mountain farm. Welsh Black and cross-bred suckler cattle: Welsh mountain sheep: methods of wintering, feeding, flock management and cross-breeding.
Redesdale E.H.F. Otterburn. Northumberland	2,300	Pennine hill farm. Blackface sheep, Galloway and Cross suckler cows. Management of stock: more intensive stocking and provision of fodder.
Rosemaund E.H.F. Preston Wynne, Hereford.	435	Mixed farm on heavy red sandstone soil. Cereals: cider apples and hops. Grazing and feeding cross-bred beef cattle and sheep. N.I.A.B. Regional Trial Centre.
Terrington E.H.F. Terrington St. Clement, King's Lynn, Norfolk.	200	Silt land arable farm. All aspects of potato production also sugar beet, beans, peas and cereals. Large White pigs. N.I.A.B. Regional Trial Centre.
Trawscoed E.H.F. Trawscoed, Aberystwyth, Cards.	808	A mixed farm on shale soils with moor. Rearing, feeding and management of Friesian dairy cattle and cross-bred suckler beef cattle; Welsh and half-bred sheep and Large White Pigs. N.I.A.B. Regional Trial Centre.
Cleppa Park E.H.S. Newport, Monmouthshire.	68	Production of soft fruit, vegetable and flower crops under local conditions in the open, and under glass.
Efford E.H.S. Lymington, Hampshire.	376	Trials with top and soft fruit; vegetables including early potatoes; glasshouse crops including tomatoes, lettuce; flower crops; irrigation.
Fairfield E.H.S. Greenhalgh, Kirkham, Preston, Lancs.	22	Glasshouse crops including tomatoes, lettuce, flowers; mushrooms.
Kirton E.H.S. Kirton, Boston, Lincolnshire.	104	Bulb flower crops including hot water treatment, storage and forcing; strawberries; vegetables, especially summer cauliflower.

Centre	*Acreage*	*Main Farming and Experimental Activities*
Lee Valley E.H.S. Ware Road, Hoddesdon, Herts.	26	Glasshouse crops including tomatoes, cucumbers, lettuce, chrysanthemums; flowers and some intensive vegetables in the open; mushrooms.
Luddington E.H.S. Stratford-on-Avon, Warwickshire.	230	Apples, plums and soft fruit, pest and disease control, nutrition and root-stocks; vegetables; flowers; glasshouse crops; irrigation; weed control.
Rosewarne E.H.S. Camborne, Cornwall.	109	Bulb and other flower crops; vegetables, including early potatoes; mobile glass-houses; shelter; weed control.
Ellbridge Sub-station, Hatt, Saltash, Cornwall.	5	The study of crops produced in the Tamar Valley.
Isles of Scilly Demonstration Station, Trenoweth, St. Mary's, Isles of Scilly.	3	Bulb crops.
Stockbridge House E.H.S., Cawood, Selby, Yorks.	161	Vegetable crops including rhubarb; top and soft fruit; crops and rotations for fixed and mobile structures; shelter; mushrooms; flowers.
National Fruit Trials, Brogdale Farm, Faversham, Kent.	180	Testing and classification of all types of top and soft fruit.

N·A·A·S EXPERIMENTAL FARMS & STATIONS

● Husbandry Farm ▲ Horticulture Station
△ Horticulture Sub-Station ⚠ N.A.A.S. Horticultural Demonstration Station

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